Investigation of good practise in road assessment, Heroad

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ABSTRACT

To manage the road network road managers and operators have to consider existing policies such as the requirement to keep the network in good condition, and to deliver this condition at minimum whole life cost. However, the condition should also meet the expectations of stakeholders. The management process has to optimise the total costs for society, whilst minimizing the effects of given condition levels on safety, reliability, environmental impact, economics and sustainability. This principle and its overall goals are equal for all road managers around Europe. *Heroad* will investigate the process (the combination of individual components, levels of assessment and the inclusion of a life cycle perspective) to incorporate also new challenges in the asset management. This includes

- Look at data collection, assessment and reporting regimes
- Considering new challenges (climate change, traffic configuration, new materials, LCC and the focus on road users expectations)
- Identify and assess the key technical components of these regimes and then determine whether they are best practice or not
- Identifying and describe indicators at different assessment levels (for road operators complicated technical parameters are okay, for decision makers and public more understandable indicators that could be built from combination of technical parameters are needed)

Then pick out the key good parts and provide advice to the customer on how they could use them. This paper will describe the outcome of the complete Heroad work.

1 INTRODUCTION

As part of the recent ERA-NET ROAD II call, ‘Effective Asset Management meeting Future Challenges’, seven projects have been awarded to address important aspects of managing the strategic road networks, i.e.

to determine the requirements and expectations of stakeholders,

to improve understanding of asset performance

the development and use of Performance Indicators for managing the network

cross-asset optimisation

The programme aims to support the change in culture of managing the road network such that there is a more balanced approach in using maintenance funds and a greater focus on customer needs. The seven projects are

- ASCAM: Asset Service Condition Assessment Methodology
- EVITA: Environmental Indicators for the Total Road Infrastructure Assets
- EXPECT: Stakeholders' Expectations and Perceptions of the future Road Transport System
- PROCROSS: Development of procedures for cross asset management optimisation
- SABARIS: Stakeholder Benefits and Road Intervention Strategies
- SBAKPI: Strategic Benchmarking and Key Performance Indicators
- HEROAD: Holistic Evaluation of Road Assessment

This paper describes the work in the latter project Heroad that aims to meet the objective to improve the understanding of asset performance.

The Heroad scope is to find **best practise** concerning **monitoring techniques** and possibilities to deliver quantifiable **technical parameters/ indicators** for use in road asset management considering the multiple practices into a coherent whole.

The Heroad project is studying the technical parameters used for the assessment of roads, bridges and road equipment. In particular, Heroad studies the measurement techniques, the robustness of the measurements and the usefulness of the resulting parameters for asset management. The impact on the environment will also be taken into account. From the analysis, examples of “best practice” in use in a particular country will be identified and put forward as a practice that could be recommended to road managers in other countries. The recently started FP7 project “Tomorrow’s Road Infrastructure Monitoring and Management” (TRIMM) will take into account the findings of the ERA NET Road (ENR) projects on asset management and, Heroad in particular.

2 GENERAL APPROACH IN HEROAD

According to PIARC (The World Road Association), asset management is defined as: “A comprehensive and structured approach to the whole of life management of assets (such as roads, bridges, tunnels, buildings, plant and equipment, and human resources) as tools for the efficient and effective delivery of services”. The European industry defines asset management as “The optimal life cycle management of physical assets to sustainably achieve the stated business objectives”. One first reflection is how PIARC’s definition aims at the “delivery of services” to users, but none of the definitions explicitly target the important environmental issues. Many definitions of asset management exist. The American Association of State Highway and Transportation Officials (AASHTO) recently released a Transportation Asset Management Guide (AASHTO, 2011) including a useful view of asset management expressed with five core questions:

- What is the current state of my assets?
- What are my required levels of service and performance delivery?
- Which assets are critical to sustained performance delivery?

- What are my best investment strategies for operations, maintenance, replacements and improvements?
- What is my best long-term funding strategy?

When managing the road network, road managers and operators have to consider existing policies such as the requirement to keep the network in good condition, and to deliver this condition at minimum whole life cost. However, the condition should also meet the expectations of stakeholders. The management process has to optimise the total costs for society, whilst minimizing the effects of given condition levels on safety, reliability, environmental impact, economics and sustainability. This principle and its overall goals are common for all road managers around Europe. Heroad looks on the assessment from the bottom up level perspective, see Figure 1.

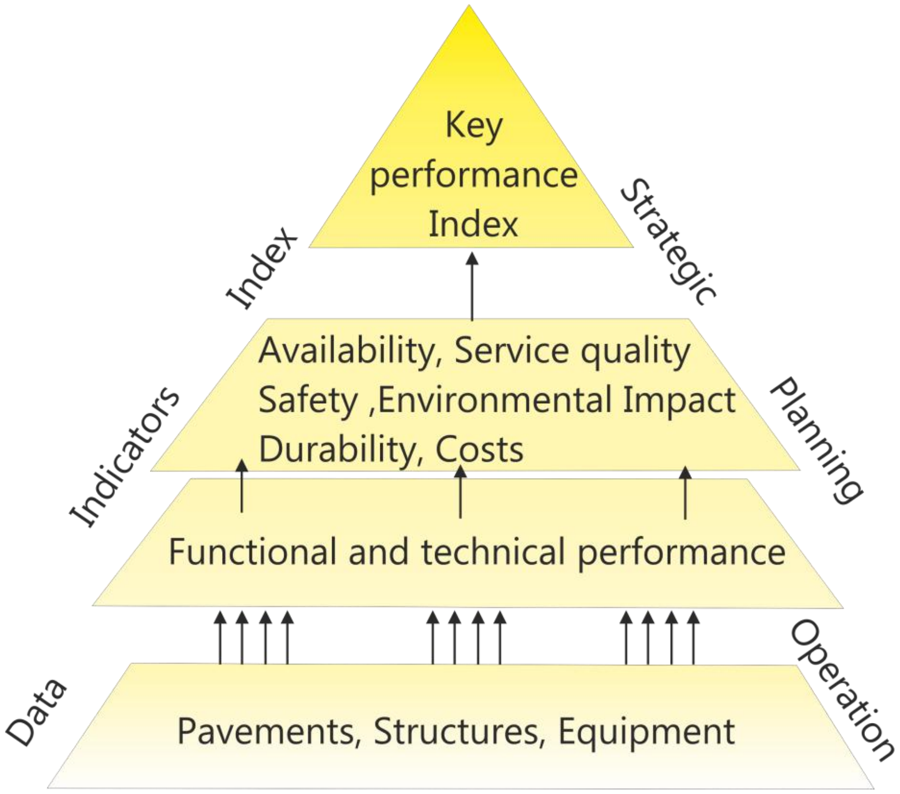


Figure 1 Data and different management levels

In Table 1 below the amount million Euros for maintenance expenditures (current prices and exchange rates in million Euros per 2009) is presented.

Table 1Maintenace expenditures in million Euros per 2009

Country	2009
Germany	n.a.
Netherlands	n.a.
Lithuania	134
Norway	1290
Switzerland*	1608
Slovenia	155
Finland	684
Denmark	866
United Kingdom	4944
Sweden	787
Belgium	523
France	2207
Ireland	45

The numbers are taken from The International Transport Forum. The figures for Switzerland are from 2008 and for all other countries 2009. Unfortunately no information was available from Germany and Netherlands. Considering those costs and including investments in infrastructure it is considerable values involved in the asset management process. Below, in Figure 2, are the maintenance expenditures share of the Gross national Product (GNP) presented.

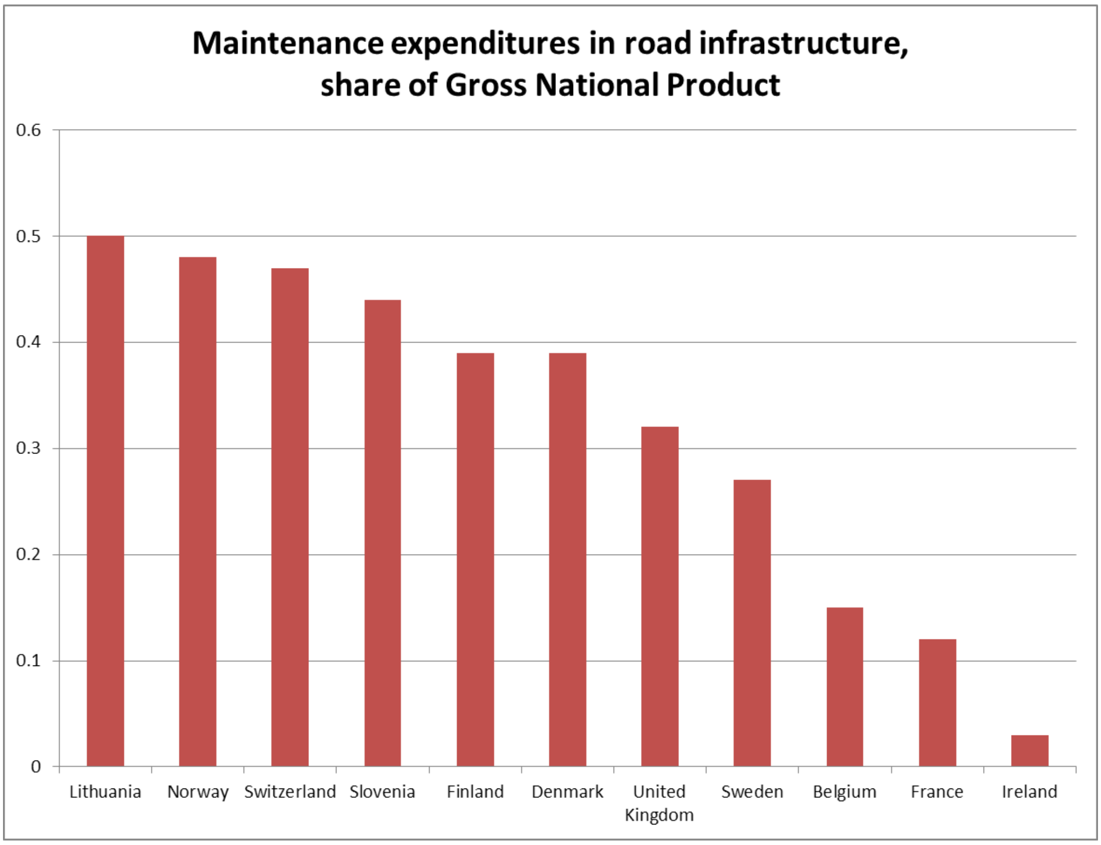


Figure 2 Maintenance expenditures as share of GNP

Tools such as PMS (Pavement management systems) and BMS (Bridge Management

Systems) have been developed to help road owners meet these goals. These tools provide a structured way to assess the condition of the network and develop maintenance plans. Many PMS also use models to assist in estimating budget levels. These management systems are typically used to develop maintenance plans for individual components of the network, such as the pavement, bridge or drainage systems. These plans need to be derived using models that employ good understanding of the way that each component (pavement, bridge etc) behaves during its lifetime. The way that management systems can be applied to road equipment, such as signs and road markings is less clear but must be considered as well. In (Mizusawa, 2009) many available commercial pavement, bridge and integrated management systems are presented and compared. Very few of them seem to consider and use an integrated cross assets possibility. Unfortunately the ranking only consider administrative functionality regarding decision support system, inventory, storage, analysis, reporting and system security, terminology and local language. It would have been useful with an assessment of functionality in a user's perspective, see Figure 3.

Rank	Pavement Management System	Score
1	Stantec PMS	79
2	PAVEMENTview	77
3	SMEC	72
4	MicroPAVER	59
5	MARCH PMS	52
6	HERS-ST	43
7	RONET	11
8	Real COST	9
	HDM-4	No score

Table 8. BMS Ranking

Rank	Bridge Management System	Score
1	Exor Structure Manager	80
2	Pontis	61
3	Stantec BMS	59
4	NBIAS	30

Table 9. Integrated Management System Ranking

Rank	Integrated Management System	Score
1	HIMS	76
2	Exor Highways	75
2	ICON	75
4	RoSy	73
5	INSIGHT	71
6	dTIMS CT	67
7	SMART	42
8	Asset Manager NT	14
9	Asset Manager PT	13

Figure 3 Ranking of management systems from (Mizusawa, 2009)

Because the European road network consists of a wide range of assets such as pavements, structures, tunnels, signs and other road equipment, a large array of approaches have been proposed to model the behaviour of the assets using many different parameters. In parallel with this, numerous methods have been suggested for including and weighting this modelled behaviour in individual management systems.

Ultimately, it would be desirable to further combine these models in an integrated management system that combines and includes all assets to assist road managers in making overall decisions that balance the needs of each component of the network. This final objective is a challenging goal. To meet the objective requires that the fundamental building blocks (the development of a good level of understanding of individual asset performance) have to be established. From these building blocks it is then possible to develop a robust integrated management system.

A further goal of a good asset management system is to provide a reliable calculation of the maintenance backlog to assist in long term financial planning. Again, to estimate the backlog requires well defined quantification of the condition using suitable parameters (and indicators). However, the level of development in this area is very different across European countries, where the climate, geographical conditions, and traffic loads vary. Previous work under the ENR programme has highlighted the importance of the robust measurements (data acquisition) and derived (condition) indices needed to deliver a reliable assessment of backlog (Maintenance backlog, 2009).

Therefore, the work in the Heroad project is focussed on developing a clear understanding of the performance and behaviour of individual assets and how this understanding can then be used to benefit asset management across Europe. In summary, the work will

- Identify and assess the parameters, models and criteria used for managing the condition and performance of assets.
- Determine how these could be used to develop common evaluation tools, through the identification and development of comparable condition assessment parameters.
- As a result, also identify those areas which could be described as best practice and determine how these could be taken forward for use in both individual management systems (e.g. PMS), backlog assessments, and ultimately within cross asset management systems.

A key focus of the work in Heroad is the influence of new technologies on the measurement of condition and how these help our understanding of condition. However, the work in the project concentrates on the requirements of Road Managers, keeping in mind the objective of providing useful, straightforward, tools that can be implemented in practice.

The environmental impact of the road network plays an important role in the overall environmental performance of many EU countries. For this reason road directors are facing increased pressure to ensure ecological sustainability and minimized environmental effects. In order to achieve the desired results it is essential to integrate environmental parameters into asset management while taking into account that they may require special consideration that is different from other functional parameters. Environmental performance often depends on the combined properties of road components which are currently managed separately. For example road pavements and noise barriers together determine the noise pollution generated by road traffic. Additionally the impending effects of climate change will in turn present additional challenges to asset management. Environmental aspects considered in the Heroad project include:

- Greenhouse gas emission (CO_2)
- Air pollutants (NO_x), particulate emissions, water and ground pollutants
- Noise emission
- Energy optimization in the following areas:
  - Road construction and maintenance
  - Fuel consumption based on rolling resistance
- Effects of climate change.

3 UNDERSTANDING PAVEMENT PERFORMANCE

The Heroad project is identifying and reviewing the range of parameters used for the objective assessment of pavements across the member groups. It is particularly considering the use of new techniques, and how these work alongside traditional methods, and also whether any environmental policies are implemented within the asset management process.

We are considering "pavements" to include the road layers, drainage and drainage systems, and associated earthworks. Current approaches applied to check that the data collected is robust and consistent are also being reviewed. This is being achieved by reviewing the training, accreditation, and quality assurance procedures applied for the assessment of road pavements across Europe, and how this affects robustness and trust in the data at both the local and network level.

3.1 Current practice

Monitoring pavement condition

Pavement surface condition parameters, such as rut depth, ride quality, texture and skid resistance are routinely measured at traffic-speed at the network level in a number of countries. However, there are other parameters, that affect the user's, or neighbour's experience of the road, such as efficiency of drains, noise, fuel consumption, spray, dust. These are not routinely measured.

Some parameters, measured by traffic-speed methods, are considered to have insufficient accuracy for use in scheme identification by engineers, e.g. cracking and fretting. Also, traffic-speed surveys may not be frequent enough to identify fast-developing surface defects, such as ravelling or potholes. In these cases, the traffic-speed data must be supplemented by visual surveys. Also, no routine traffic-speed surveys of earthworks have been identified by Heroad. Routine assessments of drainage systems are difficult to carry out because of the impracticality of inserting equipment into the drain to identify problems. Therefore it is common for only superficial checks to be carried out, or a process of cleaning and maintenance to be applied regardless of actual need, with surveying only being carried out if flooding has occurred. Similarly, pavement strength is generally measured by slow-speed, or stationary devices such as the Deflectograph and FWD and therefore routine surveys of strength are not practical on all networks. There are a number of QA regimes in place to ensure data quality, with the best checking both the repeatability and reproducibility of data.

Monitoring environmental effects of pavement construction and maintenance

The environmental impact of pavement construction and maintenance processes is linked to the overall management of these processes. CO2, air pollutant and noise emissions are to be expected in many phases like the procurement and transportation of raw materials, the preparation of the planned road trajectory and the actual construction activities. The environmental impact assessment procedures required in many countries for larger transport infrastructure projects necessitate the management of the environmental impact of individual projects. This includes e.g. the use of low-noise, low-emission construction vehicles and processes, avoidance of pollution of the surrounding landscape, the preservation of wildlife habitats, etc. The monitoring of the environmental impact on a network level is usually based on an overview of the performed projects in sustainability reports. The associated indicators are usually not directly measured technical indicators, but based on other aggregate indicators like energy consumption of construction vehicles.

The influence of pavement characteristics on vehicle emissions and noise

Road traffic noise emission at typical motorway speeds is mainly due to tyre/road noise. For this reason pavements have a large influence on the noise emission. Low-noise pavements are therefore one of the most important noise abatement measures apart from the construction of noise barriers. The use and management of low-noise pavements is usually part of a larger noise abatement policy. While the properties of low-noise pavements like porous asphalt present their own challenges in terms of maintenance, they are a very effective measure at the source and lead to reductions in the necessary extent and height of noise barriers. Therefore some EU countries, notably the Netherlands, use them extensively.

Road vehicle exhaust emissions are mainly linked to the energy consumption of road vehicles. Therefore any efforts to reduce the required propulsion energy can lead to emission reductions. Besides other effects also the pavement trajectory and road surface condition influence the road vehicle energy consumption. Slope and curvature of the road as well as the rolling resistance caused by unevenness and texture can increase the required propulsion energy. With the advent of hybrid and electric road vehicles direct emissions from the vehicles can be reduced or eliminated, however, it is still important to minimize energy consumption to avoid the emissions due to energy generation in power plants. Optimized pavements and road trajectories can contribute to this objective. However, currently the reduction of energy consumption is seen primarily as a task for vehicle and tyre manufacturers. Awareness of the potential contribution of road infrastructure operator is only slowly gaining ground.

3.2 Exceptional cases

There have been significant advances in the ability to measure pavement condition at traffic-speed in recent years. These have been achieved through enhancements in measurement areas encompassing laser, imaging, radar and acoustic technologies and the associated processing techniques. For example, the advent of reliable high-resolution transverse profile measurement systems has increased the ability to accurately measure rutting at traffic speed. In the UK the new assessments of trunk roads will require high resolution measurements as the routine output. These may offer the possibility to determine the type of rutting (i.e. structural or non-structural) from this data, and it is expected that the processing will expand to the full lane width measurement of surface texture to routinely identify raveling. The laser technologies have been applied in research carried out by a number of European institutes into the measurement of pavement deflection at traffic-speed. Advances in Denmark have led to the development of the Traffic-speed Deflectometer, which is currently being implemented on English motorways and trunk roads (Ferne et al, 2009a and 2009b), and is being introduced in other European countries, including Italy and Poland and also evaluated in Australia (Kelly and Moffat, 2012). However, whilst this device will give a network level measure of deflection, it will need to be supplemented by pavement thickness and construction, in order to calculate pavement strength. Advances are being made in Sweden in the ability to measure this at traffic speed using GPR. The importance of maintaining quality in these surveys is becoming recognised, and road operators are employing stricter regimes within their survey contracts. For example, the UK SCANNER specification for machine measured condition requires fully accredited survey vehicles and regular QA checks by an independent body.

Currently routine assessment of drainage networks is impractical. The required CCTV surveys must be carried out on a scheme level basis (usually only once flooding has occurred, to discover the cause of blockage) and require road closure, or traffic management. A novel method to measure the ability of a drain to pass water has been identified in the UK. This acoustic technique is less time consuming than traditional CCTV surveys, and requires no traffic management. It could potentially enable network level drain surveys, and accurate prediction of when maintenance or cleaning is required, thus saving unnecessary work.

Since the reduction of carbon emission is considered important, many initiated the development of carbon calculation tools for construction works. The Dutch road administration (rijkswaterstaat) for instance, developed the carbon calculation tool "Dubocalc" following the ISO 14040:2006 standard "Environmental management – Life Cycle Assessment – Principles and framework". It can be used for the evaluation of construction projects against environmental regulations, as a tool for the evaluation of the level of sustainability in the design process, or in the frame of a tender when one of the criteria concerns carbon emission.

4 UNDERSTANDING THE PERFORMANCE OF STRUCTURES

Several recent EC financed projects (BRIME, COST 345, SAMARIS, ARCHES) and PIARC committees have studied performance of structures over their lifetime and its consequence on bridge/asset management. Surveys performed within these projects indicate that level of bridge management, i.e. information and tools available, varies considerably from one European country to another. While some countries have developed comprehensive systems that apply in their bridge management systems results of monitoring, life-cycle analysis and financial issues, many others base the decisions on limited information, primarily condition of bridges. While in general information about tunnels is also satisfactory, practically no European country collects quality data about other highway structures, such as culverts and retaining/supporting walls.

Using limited data results in far from optimised assessment of bridges which consequently leads to unnecessary rehabilitation measures (strengthening, replacements) which are extremely costly and, due to the construction sites, greatly reduce mobility, traffic and road workers safety, and cause severe air pollutions.

The ambition of HEROAD is, firstly, to bring available information about the structural performance in different countries to a common denominator and, secondly, to promote the best practices of bridge and other highway structures management among all European (CEDR) countries. The focus will be on sustainable procedures, i.e. on those that are environment and user friendly and cost-efficient.

4.1 Current practice

Reconstructions of highway structures attract attention of the public and media, because they affect mobility and safety of users and have an impact on the environment. Unfortunately, in too many, if not most of the countries bridge (highway structures) management is not done in an optimal way:

- Attention is preliminary given to important (bigger) structures, while a number of interventions on smaller structures can have similar or, altogether, even more severe consequences for users and environment.
- In many countries too much focus is given to condition assessment only, while applying too conservative design rules for calculating structural safety of existing bridges and culverts. This results in unnecessary heavy interventions, such as their heavy strengthening or even replacements.
- Not enough attention is given to environmental issues and life-cycle analysis. Only in some countries constructions of bridges and tunnels are regularly classified as major road infrastructure projects which have to undergo environmental impact assessment procedures. Use of raw materials, emissions from the construction itself, changes to the local hydrology or impact on residents and wildlife are some of the impacts which have to be considered. In the operational phase emissions are mainly due to the energy consumption for tunnels and maintenance activities for bridges. Parameters are based on average maintenance frequency and required energy for continuous operation.
- Retaining walls and culverts are often not managed in a consistent way.

- Often management of structures is separate process, not treated as a part of the whole road asset management, which results in repairing a bridge one year and the road leading to that bridge in the next year.

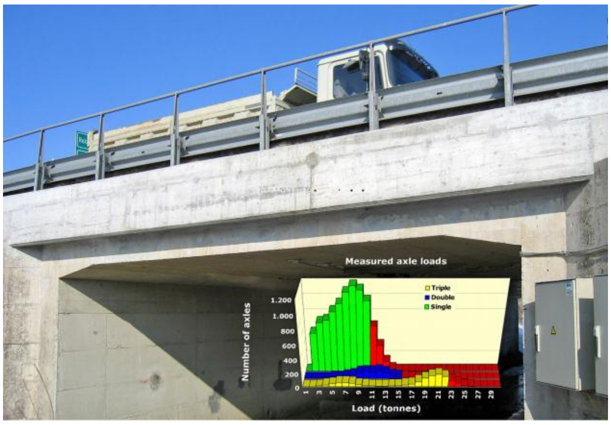
4.2 Exceptional cases

Some examples of good practice of highway structures management identified in different countries are:

- Bridge structural safety assessment procedure in Slovenia

Bridge structural safety assessment procedure in Slovenia

Two thirds of Slovenian bridges were designed and constructed more than 40 years ago for traffic loading much lower than today's traffic. As due to their age and lack of money for rehabilitation these bridges are more or less deteriorated, many of them would have to be strengthened if assessed according to the present design code (Eurocode). To demonstrate that a) actual traffic loading is less than specified in the design codes and b) that old bridges in reality behave more affordable than their theoretical models, the EC Framework Programme projects SAMARIS and ARCHES (Žnidarič, 2006 and Ralbovsky et. all, 2009) developed the soft load testing procedure. Using the cost and performance-effective bridge weigh-in-motion system to simultaneously monitor traffic and bridge behaviour, it provides realistic structural and traffic loading parameters that analytical models are calibrated to. Analysis of 20 older bridges with spans up to 20 m, where structural safety assessment based on traditional analytical procedures resulted in strengthening or heavy posting, showed that 18 of those are still safe for current traffic, while two need to be posted, but for much less than initially thought.



5 UNDERSTANDING THE PERFORMANCE OF ROAD EQUIPMENT

The objective is to identify and review the range of parameters used for the objective assessment of lighting, road signs and markings, and "technology" related assets. This includes Variable Message Signs (VMS) and infrastructure related to communication service.

5.1 Current practice

Parameters exist to measure the performance of road signs; these parameters include, for example, retroreflexion, cleanliness, and degree of obstruction (visibility). For markings, we can mention a lot of parameters, reference documents are published (e.g. Good Practice Guidance from the BRRC) and these could be used as support for the aforementioned questions. A modern technique consists in the use of a mobile retroreflectometer for the assessment of pavement markings on motorways. Durability of these markings can also be investigated and correlated with external factors such as the traffic importance and climatic parameters. To support this durability / performance analysis, evolution laws are perhaps available, one of the project's goals will then be the collection of existing laws. Lighting is also an important asset to take into account. In Sweden the Road Administration have tried organised monitoring or road markings for a number of years and are now considering a road marking management system that should be integrated with the pavement management system.

Noise barriers are the most widespread noise abatement tool for road traffic noise mitigation. Their acoustic performance is currently primarily established in the laboratory before installation. However, in the last decade in-situ acoustic test have been developed that allow the determination of acoustic performance indicators in the field. Ideally their performance should be combined with the benefits derived from low-noise pavements to allow for holistic optimization. Apart from the acoustic aspects of noise barriers their use also raises questions concerning materials used and long-term behaviour. Noise barriers area sometimes fitted with additional capabilities like with the addition of solar panels, their integration into safety barriers or specially designed surfaces to capture air pollutants. The environmental impact of other road equipment can usually been classified according to the materials used in their creation and the energy used in operation.

Safety can be increased by the introduction of “forgiving” road equipment. This kind of equipment is less robust when a vehicle crashes into it. The implementation of the “forgiving road” concept can result in less severe injuries and less deaths. Recent results of European research on this topic is presented in (RISER, 2006) and (IRDES, 2011). Road managers such as the Flemish road administration introduce these equipment’s at locations where the frequency or risk of run-off-the-road accidents is high.

5.2 Exceptional cases

The Highways Agency Carbon Account evaluates the environmental footprint of the Highways Agency activities. From the results of this analysis, some measures were identified for the reduction of carbon emission. Switching off the lighting at night reduces energy consumption. Amongst other measures reducing traffic congestion itself, better real-time information to road users about traffic jams occurring on the road network leads to better traffic fluidity and hence less carbon emissions (Richards, Kerwick-Chrisp 2010). The communication to road users can be increased by better use of VMS or information broadcasted by radio and distributed on the internet.

Also in Flanders (Belgium) the regional government decided to reduce road lightning at night and the road administration worked out a plan for the implementation of this decision. As a consequence of the reduction of lightning, a higher reflection is required from the road markings (since the beginning of 2011) and the reflectors on the road side. This illustrates well that the introduction of environmental criteria has to be integrated in asset management as a whole.

6 CONCLUSIONS

The Heroad project identified and listed currently used technical parameters and measurement techniques for road, bridge and equipment management in European countries. A deeper investigation on these measurement techniques concerned the robustness of the measurements and usefulness of the parameters for a holistic approach of asset management. Some cases were identified that could be considered as “best practices”. Some gaps were determined and for some of these the European FP7 project “TRIMM” will attempt to provide a solution.

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