THE POTENTIAL FOR EVITA PROJECT E-KPIS TO BE USED BY ROAD AUTHORITIES

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Abstract

Planning different strategies in road maintenance is one of the most important activities in road asset management. Assessment of different strategies and their comparison can be done by implementing an appropriate measure - Key Performance Indicators (KPIs). KPIs are currently used in many Road Authorities, and systematic research on the subject and development of indicators has been ongoing for many years. The Conference of European Directors of Roads (CEDR) funded project "EVITA - Environmental Performance Indicators for the Total Road Infrastructure Assets" aimed at developing and integrating new and existing environmental KPIs (e-KPIs) into the asset management process, taking into account the expectations of different stakeholders (users, operators, residents, etc.). The research focus was on environmental areas: Noise, with KPIs on day-evening-night & night noise, exposed population, population with sleep disturbance; Air, with KPIs on CO_2, NO_x, NO_2 and PM_{10} emissions; Water, with KPIs on water quality and salting of roads; and Natural resources and GHG emissions, with KPIs on resource consumption and CO_{2e} calculation. The project outputs were a set of e-KPIs produced after a comprehensive investigation of the state of the art during the project. The main benefit of this project is therefore to provide an applicable solution for the environmental assessment of different road infrastructure assets and to describe the expectations of different stakeholders in form of objective indicators. The 'User Evaluation Trial' phase of the project was used to gather feedback on the potential of e-KPIs to be used by national Road Authorities across Europe. Two Slovenian Road Authorities and one each from Denmark and Sweden were involved. The Slovenian Authorities provided input data for case studies, while all evaluated the proposed e-KPIs from their own perspective, taking into account national conditions and specificities.

Keywords: environmental performance indicators, key performance indicators, road asset management, stakeholders' expectations

1 Background

1.1 Assessment of road pavement performance

In 2004, the COST-Action 354 "Performance Indicators for Road Pavements" was initiated to define uniform European performance indicators and indices for the assessment of road pavement performance. COST-Action considered and defined several technical criteria from the perspective of users and operators. At that time Action recognised the importance of the impact that the construction and maintenance of the road network has on the environment, but at the same time not enough information was available to provide a comprehensive result [1].

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Research on (key) performance indicators was later complemented during the project EVITA "Environmental Performance Indicators for the Total Road Infrastructure Assets". The main objective of the project was to develop and integrate environmental KPIs (e-KPIs) into the asset management process, again taking into account the expectations of different stakeholders.

A priority for the project was firstly that the e-KPIs should be easy to understand and use, and secondly that they could be used to manage the full range of road infrastructure components - pavements, structures, road furniture etc. EVITA defined E-KPIs for four main categories and developed recommendations for the implementation and use of performance indicators [2].

1.2 Main groups of environmental performance indicators

The EVITA project started with a comprehensive investigation of the state of the art in collaboration with European Road Authorities and with other key stakeholders in road sector. In a second step, various e-KPIs for the environmental domains "Noise", "Air", "Water" and "Natural resources" were further developed and described in detail in one of the reports [3].

1.2.1 Noise indicators

The developed e-KPIs are based on noise mapping, using data from both sound level measurements and modelling. A three-level indicator was developed for noise impacts: The Emission indicator is based on physical measurements of noise levels, the Exposure indicator is based on noise exposure and thresholds, and the Impact indicator is based on noise exposure and "annoyance".

1.2.2 Indicators for air pollution and greenhouse gas emissions

Air pollution can be generated by traffic itself, throughout the life cycle of the infrastructure, or by construction and maintenance activities that take place at specific times. For the proposed e-KPI, calculations of NO_x, PM and CO_2 emissions (in t/km/yr) are needed. The technical parameters are total vehicle emissions per km of road.

Separate e-KPIs are proposed for PM and NO_x on the one hand, and CO_2 as a greenhouse gas on the other: an emission rate indicator for NOx and PM, based on modelled total emissions using traffic data and vehicle emission factors; and an exposure indicator for NO_2 and PM_{10} reflecting health impacts, based on an assessment of the population exposed to concentrations above EU limits.

The proposed e-KPI for CO_2 emissions from vehicles is based on the amount of CO_2 generated by road transport, using the same methodology as the emissions e-KPIs for air quality.

1.2.3 Indicators for water pollution

Water pollution from road infrastructure is mainly due to the wash-off of pollutants from the road surface and can be mitigated by protective measures related to the drainage system. Indicators can be developed depending on the quality of the drainage system and associated pollution control measures. Activities such as the spreading of salt and the sensitivity of the environment into which run-off is discharged must also be considered.

Two indicators are proposed: Water quality, based on an assessment of pollution load, environmental sensitivity and drainage system quality; and Salt, based on a comparison of salt load for the road section being assessed against the network average, weighted by local requirements and environmental sensitivity.

1.2.4 Natural resources indicators

Natural resource use in road infrastructure is mainly associated with material and energy consumption and waste generated during construction and maintenance. Care must be taken when developing indicators to avoid perverse results, e.g. encouraging unduly long transport of recycled material when new aggregate is available locally, so the indicator must take full account of life cycle impacts. Two indicators are suggested for use if the user has all the necessary data available. Material Resource Efficiency Indicator (MREI) is used to calculate the recycled content of the construction material, which is weighted to represent the relative impact on natural resources as a proportion of the total materials used. Embodied Carbon Reduction Indicator (ECRI) is used to compare the reduction in CO_2 emissions for a maintenance strategy to a nominal strategy that would have the maximum CO_2 emissions.
Greenhouse gases released into the air during maintenance or construction activities are also considered in this section.

1.2.5 Guideline for use of indicators

To guide the application of each indicator, so-called application sheets have been prepared alongside worked examples. An application sheet contains information needed to calculate the KPIs and recommendations for their practical application. The main elements (data groups) included in the application sheets are: Identification of the indicator (information on its use and application), Input data collection (parameters needed for the calculation), Calculation procedure (equations, transformation functions to determine a dimensionless index from 0 as very good to 5 as very poor), Output and use (context in which the e-KPI is used) and References. Figure 1 shows part of such an application sheet, Calculation procedure, for the environmental index for noise pollution Day-Evening-Night.

3. Calculation procedure		
Pre-calculation:		
Technical parameter:		$TP_{Noise,den} = 100 \cdot \frac{n_{den,i}}{n_{den}}$
Transformation Function:		$EPI_{Noise,den} = 0.05 \cdot TP_{Noise,den}$ with $[0 \le EPI_{Noise,den} \le 5]$
Description	$TP_{Noise,den}$	*Technical parameter for the percentage of people along the road section exposed to a Day-Evening-Night noise level higher than the threshold* $L_{den,threshold}$
	$EPI_{Noise,den}$	*Environmental index for Day-Evening-Night noise exposure above the threshold*
	$EPI_{Noise,den} = 0$	*All neighbouring people are exposed to a noise level below the threshold*
	$EPI_{Noise,den} = 5$	*All neighbouring people are exposed to a noise level above the threshold*

Figure 1 Part of Application sheet (extract from [2])

2 Trials for evaluation of E-KPIs

Slovenian Infrastructure Agency (SIA) and Motorway Company of the Republic of Slovenia (DARS) participated in a trial to evaluate the e-KPIs proposed by EVITA. The first Authority manages the Slovenian national road network with the exception of motorways, while the second Authority manages the motorway network separately. The aim of this experiment was to evaluate the relevance of the e-KPIs for the NRAs (strategically), to investigate the data availability to support the selected E-KPIs, to analyse the data and to comment on their usefulness. The focus of the work was on E-KPIs for noise, water quality and salt consumption.

2.1 E-KPI group: Noise

This group consists of 4 E-KPIs: $EPI_{Noise,den}$, $EPI_{Noise,night}$, $EPI_{Noise, \% HA}$ (high annoyance residents), and $EPI_{Noise,HSD}$ (high sleep disturbance residents).
While both Authorities expressed strong interest in all e-KPIs, the available data depends on the policy driver - the EU Noise Directive [4] and its requirements. EU member states are required to produce strategic noise maps for all major roads with more than six million vehicle passages per year. This means that input data were available for few road sections managed by SIA and for most sections managed by DARS. If we take this into consideration, it can be said that this group of e-KPIs was the easiest to calculate as all the required data is available. From the perspective of the results, the E-KPIs show a good situation, especially in terms of the percentage of people highly annoyed by noise and the percentage of people whose sleep is disturbed by high noise levels. Looking at the results specifically for the motorway network, they also show a very good situation. This is not surprising when one knows that at the time of writing the case studies a large part of the motorway network was completely new and that the noise problem was solved in many places by installing noise barriers.
Figure 2 shows an example of trial results - motorway network with $EPI_{Noise, night}$ for motorway sections for which noise maps were available. The noise ranges (see legend) were chosen for experimental purposes only and do not reflect Authority policy or preferences.

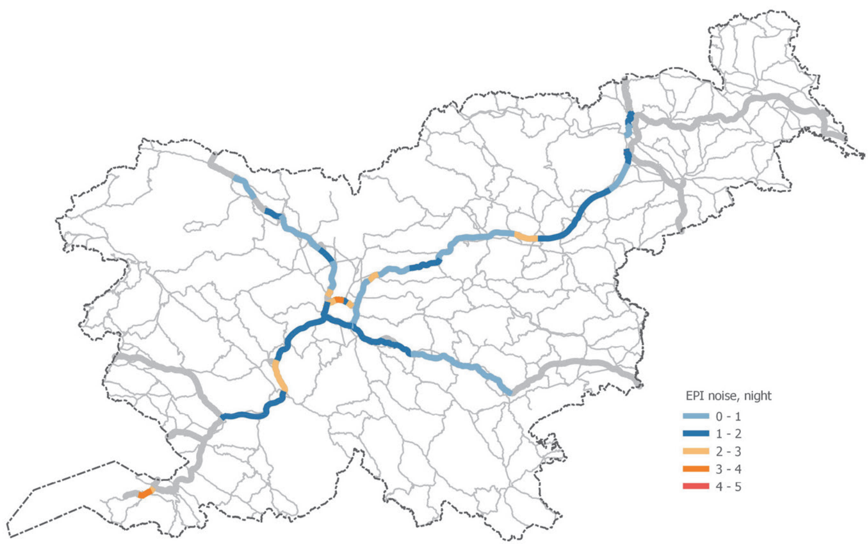

Figure 2 $EPI_{Noise, night}$ for motorway sections in Slovenia

2.2 E-KPI group: Air quality and CO_2 emissions

This group consists of 5 E-KPIs: $EPI_{Emissions,CO2}$, $EPI_{Emissions,NOx}$, $EPI_{Emissions,PM}$, $EPI_{Emissions,NO2}$, and $EPI_{Emissions,PM10}$. Both Authorities expressed low to moderate interest in all e-KPIs. In all cases, some data are available, but the estimate is that high costs would be necessary to complete the data.
Emissions data for roads (own data sets on vehicle emissions) were not available for either Authority. The estimate is that both the emissions data and the model data are associated with high costs that would require external resources. It is assumed that the current low level of interest will increase over time.

2.3 E-KPI group: Water quality

This group consists of 2 e-KPIs: EPI_{Water} and EPI_{Salt}. For the first there is some data and low interest at SIA (high for groundwater sensitive areas), while for the second there is high interest and almost all data available for calculation.
EPI_{Water} is quite complex and requires relatively detailed input data. There is generally no problem with collecting traffic data, but rather qualitative assessment data. This relates to information on the type of runoff, ability to handle risk volumes, structural condition, and operational status. As these data are not always available, the calculation was only carried out for a single case (a detention basin).
During the construction of the motorway network, special attention was paid to the drainage system, among other things. Therefore, DARS was very interested in the future collection of input data and calculation of EPI_{Water}.
The average amount of salt on individual road sections and on the entire road network is routinely recorded by both NRAs. SIA has in the past developed a system to track salt use during winter maintenance, which has resulted in little interest in implementing EVITA's proposed EPI_{Salt}. On the other hand, DARS is interested in the possibility of comparing salt consumption between regional maintenance bases. Figure 3 shows schematically motorway sections managed by specific regional maintenance bases.

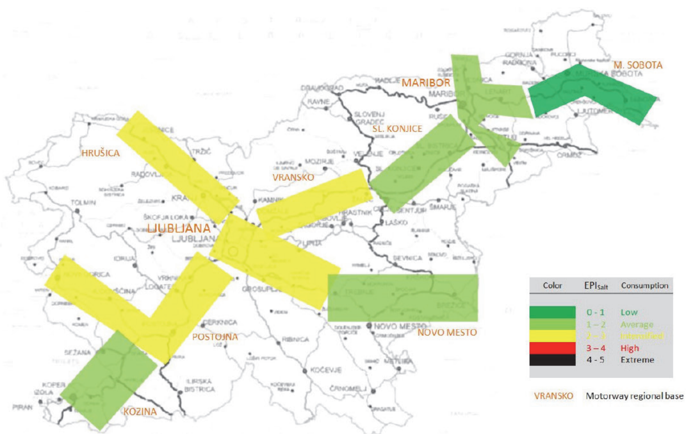

Figure 3 Scheme of calculated EPI_{Salt} on motorway network

Salt consumption ranges (see legend) were chosen for experimental purposes only and do not reflect DARS policy or preferences.

2.4 E-KPI group: Natural resources

This group consists of 3 e-KPIs: $EPI_{Resources}$, EPI_{ECR}, and CO2e. For all these e-KPIs, it was assumed that data is difficult to obtain, therefore the interest in calculating these e-KPIs is low. No study has been conducted to calculate these e-KPIs. While other e-KPIs can be used well for implementation on whole road networks, the e-KPIs for natural resources are highly dependent on local conditions. Different maintenance or construction strategies, different production practices, pavement designs, available materials, electricity mixes, and other region-specific elements all contribute to differences in calculated results and make them difficult to compare. As the focus on environmental sustainability increases, the collection of input data should improve.

3 Additional feedback from road authorities

A summary of the feedback received from the Danish and Swedish Road Authorities is presented here for each group of e-KPIs.
In Denmark, data is available for all noise e-KPIs and the Authority is very interested in all of them. However, they approach the noise issue somewhat differently and in the future they may look at the differences and the advantages and disadvantages of both systems.
In Sweden they are in favor of the proposed indicators $EPI_{Noise,den}$ and $EPI_{Noise,night}$. However, the indicators are not very suitable for Swedish conditions and therefore there is little interest in implementing them. Inventory and monitoring in Sweden is based on a Swedish measurement methodology, which is different from the proposed indicators. Another reason for the low interest is that, due to the EU Noise Directive, there are inventory data of the road network above 3 million vehicles per year, which would make it possible to calculate EPIs for these roads. However, it must be said that this only applies to a small part of the Swedish state road network. The noise experts find that the $EPI_{Noise,\ \%\ HA}$ and $EPI_{Noise,HSD}$ are generally very well designed indicators. Specifically for the purposes of pavement management practice, the indicators are not useful because pavement management in relation to noise in Sweden is based on Cost Benefit Analysis.
In Denmark, the data for calculating the indicators from the air quality and CO_2 emissions group were not readily available. However, they were keen to learn from this group of e-KPIs.
In Sweden, HBEFA was used at the time as an emission model that can be used at the network level down to the detail level when in-data is available, and SIMAIR, a Swedish model developed by SMHI (Swedish Meteorological and Hydrological Institute) to calculate concentration (dispersion model) and be able to estimate dose and impact of emissions. Using the calculation sheet to convert to the e-KPI would be straightforward once one has the in-data (emissions or exposure), but requires external resources. Therefore, there has been little interest in indicators from this group.
Almost all the data is available for calculating the indicators of the water quality group in Denmark, and they are also keen to learn from this group of e-KPIs.
According to the water specialists from the Road Authority in Sweden, the indicators seem to be well designed. Regarding the indicator for water quality and drainage systems, it is possible to acquire the in-data on drinking water resources in many places. The proposed indicators show a strong similarity to the risk assessment system developed and used by the Authority. In their system, additional consideration is given to how many people use the water resource and whether there are alternative resources. They also have data available that can be used to calculate EPI_{Salt}.
Similar to the water quality indicators, Denmark is very interested in learning from the natural resource e-KPI group as well. They kind of have data available, although the right data is hard to retrieve.
Natural resources and indicators are an area of high interest and focus in Sweden, as at the time they were developing their own climate calculator to be able to calculate CO_2 emissions from construction, maintenance and operation of road (and rail) infrastructure. One comment on this group was that all separate e-KPIs could also be a common one.

4 Conclusions

The EVITA project developed and provided a set of environmental KPIs and a practical guide for their use in pavement management practise, together with ‘Application Sheets’ with essential information that a user can pick up and use if interested in applying an indicator. During the user evaluation trial, it was found that for the calculation of some indicators, data was readily available, for some reasonably available and for others difficult to obtain.

As the project was completed some time ago, this situation may have largely improved as international environmental awareness has increased significantly over time. In adopting the proposed indicators, it is also important to keep in mind that they are either site-specific or global. This is important because a global indicator generally impact an entire organisation, while a site-specific indicator generally only impacts very specific mitigation measures at that site.

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