EVITA: ENVIRONMENTAL KEY PERFORMANCES INDICATORS

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ABSTRACT

The main objective of the project "EVITA – Environmental Performance Indicators for the Total Road Infrastructure Assets" is to develop and integrate new and existing Environmental Key Performance Indicators (E-KPIs) in the asset management process, taking into account the expectations of different stakeholders (users, operators, neighbours, etc.). The project has been structured in four phases:

1. An extensive inventory of the so-called road stakeholders and of their expectations;
2. An inventory of the existing E-KPIs
3. Some recommendations of different new E-KPIs for the environmental areas "noise", "air and water" and "natural resources and greenhouse gas (GHG)"
4. Some recommendations for the implementation and the use of E-KPIs.

The paper mainly reports on the three first phases of the project, being said that the third phase was still on going at the time this paper was written

A first list and definition of road stakeholders is proposed, largely based on recent PIARC and COST documents. These stakeholders are spread in categories and sub-categories when this classification proves to be helpful to correctly understand and identify their expectations. Then, the expectations from each stakeholder are listed, and their relative importance is evaluated. The need for environmental related E-KPIs is derived from this analysis inventory.

On basis, the inventory of existing indicators started from previous works, such as the one done in the COST 354 action. Beyond this work, a number of sources were considered in the inventory. Performances of these existing KPIs were assessed as far as the available information made it possible.

This work opens the road for the development of missing E-KPIs, dealing with: 1) Noise produced by road network management; 2) Air and Water pollution due to road network management and 3) Natural resources - including energy - consumption.

The implementation of them in Pavement and Asset Management Systems is starting and will be reported in future papers.

1 INTRODUCTION

Road operators have to report, more and more frequently and efficiently, to all road infrastructure and transport stakeholders. This includes the road users and the road owners, but also, to an increasing extent, the people living adjacent to the road network and all bodies which ultimately are influenced by the road network. Beyond the provisions of satisfying asset preservation and user safety, needs and expectations expressed by all these stakeholders more and more deal with socio-economic development and environment preservation. It is thus likely that sustainability considerations will feature more and more highly in asset management in the immediate future. As an example – but it is only one example amongst a others –, the regulatory requirements for greenhouse gas (GHG) reporting is becoming more challenging and a greater awareness of carbon dioxide production is beginning to influence procurement decisions within many industrial activities, including transport. By developing Key Performance Indicators (KPIs) which reflect the various impacts of all road activities (construction, operation, maintenance) on the environment and setting in place a framework for appropriate and efficient implementation of these Environmental KPIs (E-KPIs), it will be possible to establish a common approach to the use of sustainable development indicators in Europe.

In this context, the "EVITA – Environmental Performance Indicators for the Total Road Infrastructure Assets" project, which is conducted under the auspices of the Road ERAnet 2 research programme and funded by a group of European Road Administrations, has three main objectives:

- To develop and integrate new and existing Environmental Key Performance Indicators "E-KPIs",
- To identify the best practice in the application of E-KPIs and
- To demonstrate how these indicators can be implemented in practice.

From the beginning, it was decided that the EVITA project will focus on the development and implementation of technical well-shared key performances indicators dealing with:

- Noise produced by road network management;
- Air and Water pollution due to road network management;
- Natural resources - including energy - consumption.

Beyond the general structure and methodology of the project, the paper mainly reports on the three first phases conducted in the project, which are:

- The extensive inventory of the so-called road stakeholders and of their expectations;
- The inventory of the existing E-KPIs;
- The development of new E-KPIs; taking into account the progress of this phase when the paper was writen, only the main axes and specifications of this development are addressed.

2 EVITA METHODOLOGY

The methodology adopted in EVITA was mainly based on a stepwise top down approach. It can be expressed as: "From the stakeholders to the technical elementary indicators, via the expectations and the KPIs".

The consortium took largely benefit from the works done by PIARC (World Road Association) sub-committee D1.2 (see Lepert, et al. (2011)) to list the road stakeholders and their expectations, and to identify the needs for KPIs. An extensive literature study was then

conducted to inventory existing KPIs, which could bring relevant answers to some of the KPIs identified in the previous step. The works done in COST 354 [Litzka, et al. (2008)] was used as background too. In principle, the differences between the list of required KPIs (from stakeholder analysis) and the list of existing KPIs (from literature study) was supposed to point out the needs for new E-KPIS.

However, the objective of EVITA was not to create new E-KPIS ex nihilo. On the one hand, the project was too short to conduct all the necessary researches, developments and validation processes required to build such indicators. On the other hand, a large amount of work had already been done which produced scientific and, sometimes, technological bases for that. European standards and directives had also to be taken into account to provide Road Administrations with KPIs that they could efficiently use in the European context. Therefore, the development of "new" environmental key performance indicators, within the project, mainly consisted in:

- Gathering all the available documentation on the measurement / assessment of environmental impacts of road asset management (scientific reports, regulations, European directives and standards, etc.);
- Processing this documentation to propose one or several new E-KPIs to assess emissions of GHG and particles, noise generation, preservation of natural resources (by using recycling, for instance), etc.;
- Describing the procedures to collect the basic technical data require to calculate each indicator and, when possible, propose some options to substitute "cheap data" (or data which are already collected for some other purposes) to expensive ones.

An important aspect of the programme was the implementation and use of the proposed KPIs. The general framework proposed by EVITA for implementation of E-KPIs was based on a flexible system that can accommodate different types of technical parameters and indicators, different objectives and different levels of application. Especially, the use of a unified scale to express E-KPIs was recommended. Based on the work previously performed under COST 354 action, some guidance was provided for the transformation of technical parameters into unified E-KPI, as well as for the combination of several E-KPIs into one "Combined Index", when needed. This part of the project ended with general recommendations concerning the integration of E-KPIs in asset management practice, depending on the specific objectives.

One should note that an important condition for the success of the project was the intensity of the exchanges between the project consortium and the European Road Administrations (ERA). Several workshops were organized to associate the ERA to the progress of the project.

3 STAKEHOLDERS, THEIR NEEDS AND THEIR EXPECTATIONS

Surprisingly, there were not so many attempts made, in the past, to rationally and extensively inventory all road stakeholders and their expectations. Since decades and decades, road operators had been considered, and considered themselves, as the central actors of the road management, collecting and processing more or less informally the needs and expectations of all people concerned by road operations. The road users were recognised as primary and almost only road stakeholders. In France, where users associations such as Touring Club, were not very active, the expectations and requirements of users were mainly expressed by politicians, often under the pressure of media. Even fleet operators and other professional users (taxi and bus companies) met some difficulties to be directly ear by road operators, except when they were expressing via the two former channels (politician and media).

As a consequence, and until recently, road stakeholder's identification was not largely addressed in literature. The work initiated and conducted by PIARC, in the 2000's, appears to be one of the first rational and extensive approach of this problem. The last Technical Committee D1, on "Road Asset Management", specially addressed this problem from 2007 to 2011. The second Working Group of this TC ("Management Indicators") was in charge of identifying the so-called "High Level Management Indicators" (HLMI).

This concept of HLMI is closed to the concept of KPIs addressed by the EVITA project. EVITA completed the PIARC report, using the outputs of a workshop and of a questionnaire, to set a list and definition of road stakeholders. These stakeholders were spread in categories and sub-categories when this classification proved to be helpful to correctly understand and identify their expectations. For instance, within the category of "Users", daily users certainly feel more concerned by the congestion at the rush hours than tourists. Vulnerable users are more sensitive to the quality of specific facilities (such as cycle tracks) than the other users. Figure 1 summarizes this inventory. The expectations from each type of stakeholders were listed and organized as displayed in Figure 2.

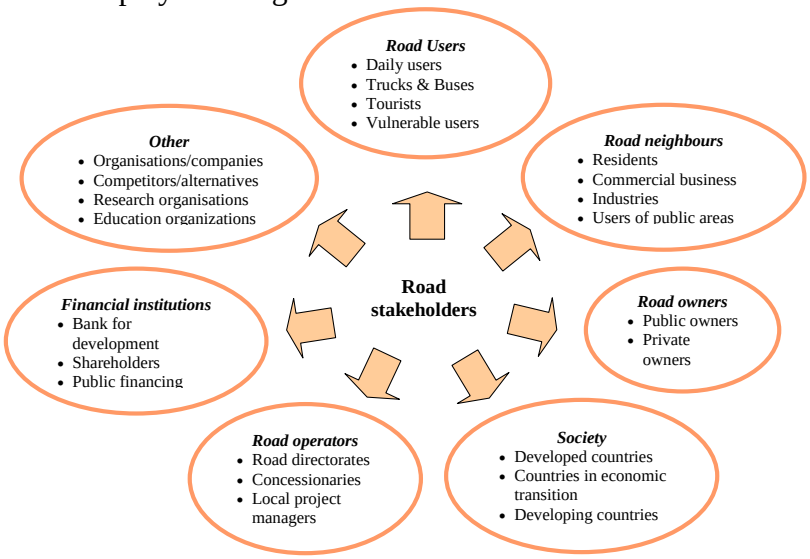

Figure 1 – Inventory of road stakeholders

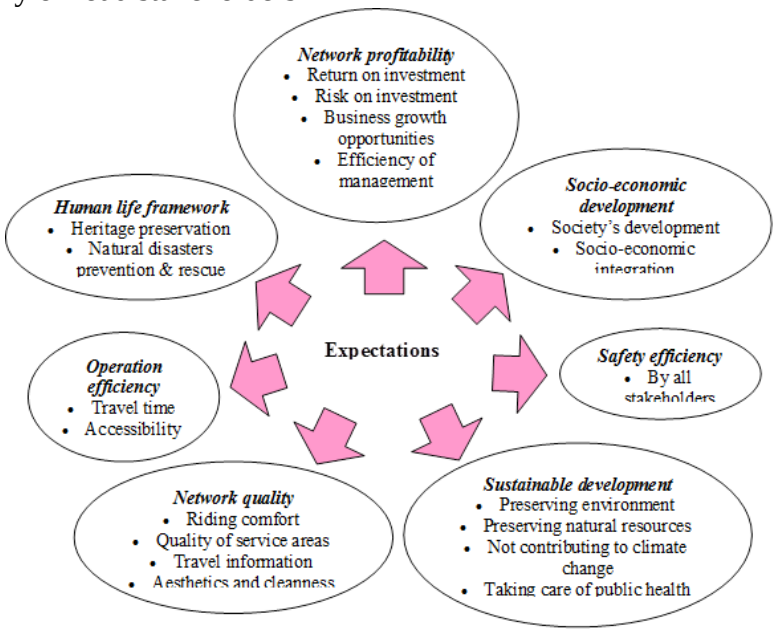

Figure 2 – Inventory of road stakeholder's expectations

A more comprehensive analysis made it possible to assess the relative importance of the different expectations for the different stakeholders. Figure 3 qualitatively expresses this link. Clearly, as far as environmental impact is considered, expectations are expressed by three stakeholders: the neighbours, the Society and, to some extent, the owners. However, these latter ones probably reflect the expectations of the two former categories.

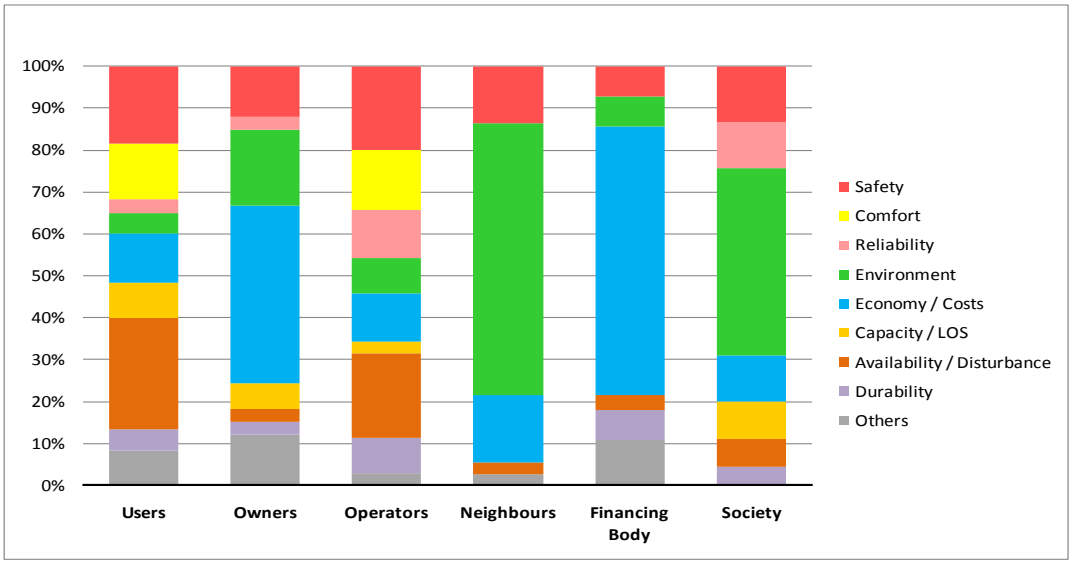

Figure 3 – Stakeholder's expectations (EVITA-workshop 2010)

4 EXISTING E-KPIS, NEEDS FOR "NEW" E-KPIS

The need for environmental related E-KPIs was derived from the former inventory. The inventory of existing indicators started from previous works, such as the one done in the COST 354 action. Beyond this work, a number of sources were considered in the inventory. Other recent COST actions (350, 351, 356, etc.), European research projects (SILVIA, SILENCE, POLMIT, HEATCO, aspect, etc.), existing tools (ASJ RTN-Model 2008, PaLATE, BE²ST-in-Highways, etc.) were reviewed, and some specific studies too, from COLAS, FINNRA, EEA, etc. Based on this investigation a detailed assessment of existing E-KPIs was conducted comprising information about the following topics:

- Noise (4 different E-KPIs);
- Air pollution (1 E-KPI);
- Water pollution (3 different E-KPIs);
- Natural resources (2 different E-KPIs);
- Greenhouse gas (1 E-KPI).

This work opens the road for the development of missing E-KPIs (WP3) and the implementation of them in Pavement and Asset Management Systems (WP4), which will be able to develop their contribution to EVITA.

5 PROPOSAL FOR NEW E-KPIS

5.1 Recommended definitions and general approach

Based on the positive experiences within the COST 354 project and the possibility to integrate the environmental aspect into a full holistic assessment process the recommended

general approach will be based upon the method of COST 354. In the following Figure 4 the process for the assessment of characteristics of road infrastructure assets are schematically shown.

With regard to COST 354 [Litzka, et al. (2008)] "Performance Indicator" is used a superior term of a technical road characteristic, that indicates the condition/situation of it. It can be expressed in the form of a "Technical Parameter" (TP) (dimensional) and/or in the form of an "Index" (dimensionless). The "Technical Parameter" is a physical characteristic of the road, derived from various measurements, collected by other forms of investigation, or calculated from theoretical models (e.g. noise expansion calculation). For the transformation of the "Technical Parameter" into the dimensionless "Performance Index" (PI), "Transformation Functions" or "Transformation Processes" will be used. The output of the "Transformation" will be the "Performance Index", which can be defined as an assessed "Technical Parameter" of the road in form of an, dimensionless number or letter on a scale that evaluates the "Technical Parameter" involved on a 0 to 5 scale, 0 being a very good condition/situation and 5 a very poor one.

Based on a unified classification it is possible to combine different indices into Combined Indices (CPI) and finally into a General Performance Index (GPI).

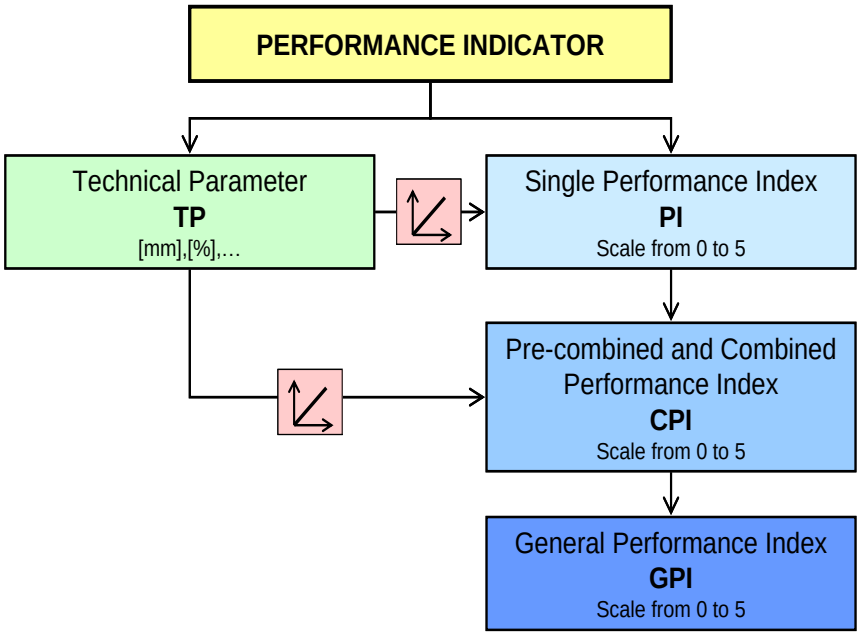

Figure 4 – Overview of the development of performance indicators in the COST 354 action [Litzka, et al. (2008)]

The next step in the process is the definition of "Combined Performance Indices", derived from the single PIs. The objective of each "Combined Environmental Performance Index" (E-CPI) is to characterise the contribution of each environmental area to the total environmental situation or performance respectively of the road infrastructure asset.

At the highest level in the assessment of the environmental performance is the calculation of the "General Environmental Performance Indicator" (E-GPI). The GPI is a mathematical combination of single and/or combined indicators which gives a first impression of the overall environmental situation at network level, and enables badly performing sections to be identified. By using this information a general design or maintenance strategy can be derived.

Consequently the general indicator is a useful tool for decision-makers to assess the environmental condition of the network and to evaluate future strategies

In comparison to COST354 where the Technical Parameters and Indices have been related to the pavements only, the E-KPIs will and must go beyond the reference to single sub-asset. E-KPIs should represent the environmental performance of a road section, of a partial road network or of the whole road network. Of course, the environmental performance is strongly dependent on the number and types of different sub-assets. But the E-KPIs should represent the overall situation in form a cumulated value of all single parameters to be found on the section, the partial road network or the total road network.

5.2 Noise E-KPI

Noise E-KPIs were the most advanced development at the time the paper was written. Environmental noise can have a number of negative effects on health, ranging from sleep disturbance to cardiovascular disease. A recent report from the World Health Organization and JRC (2011) has shown that several healthy life years are lost in Europe due to environmental noise. The Environmental Noise Directive 2049/49/EC (2002) (END 2049/49/EC) aims to provide a common basis to all Member States for assessing noise problems across the EU through monitoring and mapping noise levels and drawing up subsequent action plans.

Within the framework of EVITA project, it is planned to define or recommend an E-KPI, which takes the effect of road traffic noise on the population into consideration. The END commits all countries to assess noise from road sources in agglomerations and in areas around major roads. The main steps for noise assessment proposed within EVITA in accordance with the END are the following:

1. Define the geographical local area exposed to road noise: raw map and buildings, topography, meteorology, surroundings of the road, density of population;
2. Collect data about the road infrastructure: traffic volume and distribution, speed, type of the road surface, noise barriers;
3. Evaluate the exposure of population to road traffic noise via a model of emission and propagation recommended in the country or by the Common NOise aSSessment methOdS (CNOSSOS) recommended by the EU [Kephalopoulos S., et al. (2010)];
4. Calculate the E-KPI for noise (below).

The E-KPI to be proposed by EVITA for road traffic noise should reflect the current noise exposure of the population along the network using the data of the European Directive as input. Ideally, the environmental noise indicator should include the density of population by categories (i.e. adults, children, ill peoples…) and/or the nature of buildings (dwellings, schools, hospitals). However, in practice the available data will only give the total number of people per noise bands without distinction in the categories of people. Moreover the details on the nature of buildings are not systematically available. Thus, in a first approach, it seems reasonable to limit the E-KPI for noise to the percentage of population affected by road traffic noise in a given area. A second key point in the definition of the E-KPI by EVITA is how the current noise situation respects the legal or recommended noise thresholds within the studied area. This is a major parameter for action plans and improvement of the infrastructure with regard to road traffic noise. A third key factor is the annoyance of the exposed population which should be taken into account in the calculation of the E-KPI for noise. Based on these requirements, the following “Technical Parameters” for the assessment of the noise situation are planned to recommend:

- The "Technical Parameter" for L_{den} noise level in a given area is defined as the probability for a person living in this area to be exposed to a noise level L_{den} higher than the legal (or recommended) threshold $L_{den,threshold}$
- A second "Technical Parameter" for L_{night} noise level in a given area can be defined as the probability for a person living in this area to be exposed to a noise level L_{night} higher than the legal (or recommended) threshold $L_{night,threshold}$
- Another alternative for the definition of the "Technical Parameter" is the percentage of the exposed population annoyed by the road traffic noise. The exposure-response relationships can be found in Miedema H.M.E., et al. (2001) and gives the percentage of annoyed people ($\%A$) as a function of the L_{den}.

According to §5.1, for the calculation of an index, the technical parameters can be transformed to a scale from 0 to 5, where 0 is the best situation (i.e. nobody is annoyed by noise) and 5 is the worst situation (i.e. everybody annoyed by noise).

5.3 Air pollution and GHG

At the time this paper was written, the work on Air and GHG indicators was still on progress and insufficiently elaborated to be reported here. This will be done in later publications.

5.4 Water pollution

These family of KPIs development is still under construction. However, based on the discussion within the workshops, the MC-meetings and the working group meetings, it is planned to define an E-KPI for water which reflects to the following two issues:

- Use of salt in the context of winter maintenance;
- Drainage system and water management.

The use of salt on a road section is dependent on main factors like climatic situation, type of road, speed, traffic volume and location. Especially in those countries where intensive winter maintenance is necessary, the use of salt is an important safety and cost factor. Thus, it is difficult to assess the situation just on the amount of salt to be used on a road section, which is strongly dependent on the actual winter situation. Furthermore this can (will) change from year to year. Accordingly, an indicator for use of salt should detect those areas (road sections), where the amount of salt to be used is much higher than in other areas or regions, but taking into account the local situation. The basis for the calculation of the recommended "Technical Parameter" will be the average amount of salt to be used on the assessed road section in comparison to the average over the whole road network. The average values should be calculated for a longer time period, where a minimum of 5 years is recommended. An additional weight enables to assess the local situation according to the sensitivity of the area (around the road section) and the intensity of winter maintenance in this region.

The assessment of the drainage system of a road section from the environmental point of view could be a complex process. Especially, if the effect of polluted water in a certain area will be assessed, a high number of individual or strongly dependent input parameters must be collected (if possible). For a general, pragmatic assessment only those data should be taken into consideration, which are available for a high percentage of the road network. The following parameters should be used in any case:

- Type and condition of drainage system;
- Functionality and efficiency of drainage system;
- Traffic volume and percentage of transported dangerous goods;

- Sensitivity of area according to water pollution (e.g. fresh water area);
- Intensity of rain falls (climatic situation).

The different influencing factors show different dependencies. To provide a holistic approach, a stepwise procedure offers such a pragmatic solution. The following aspects can be assessed individually and finally brought together by using a combination procedure according to the recommendations within COST 354:

- Assessment of drainage condition (structural assessment) and functionality;
- Assessment of normal efficiency of drainage system;
- Assessment of efficiency of drainage system in case of accidents with dangerous liquids or goods (stress test);
- Assessment of maintenance of drainage system.

Because of a lack of detailed unified "Technical Parameters" the assessment could be based on a verbal description of each single aspect in relationship to the scale of 0 (very good) and 5 (very poor). The output of the assessment can be combined, weighted according to the local situation (traffic, climatic situation, risks of accidents with dangerous goods, etc.).

5.5 Natural Resources

The work is still on progress. For non-renewable resources there are some possible indicators stated like rareness of resources, energy content of resources, mineral concentrations, degree of use of flow resources in relation to the size of the flow, total material requirement and indicators related to other categories, such as energy requirement or land use. EVITA decided to group non-renewable resources indicator into 5 types of indicators:

- energy and mass,
- material use and deposits,
- future consequences of resource extractions,
- energy consumption or entropy production, and
- marginal increase in costs due to the extraction of a resource.

An important part of developing E-KPI for natural resources preservation is taking into account material that has been reused, reclaimed, recycled or down cycled in the road pavement construction. Indicators, aiming at measuring the environmental impact of construction materials and products, can generally be grouped according to DEFRA (2009) into indicators that measure a specific environmental parameter, and compound indicators (like combining approach that EVITA follows).

In line with the EVITA's objectives it is planned to define or recommend E-KPIs that could be applied in practice and that would take energy consumption into account, give credit to recycling/reuse/down cycling and be in line with the life cycle assessment. For the definition of E-KPIs in the area of natural resources the following two recommendations are planned:

1. E-KPI taking into account mass: The "Technical Parameter" for natural resources based on masses is calculated for each road pavement layer from the amount of recycled material and weighted upon some elements that relate to environment sustainability. The technical parameter supposedly gives credit to higher use of the recycled material, especially in regions where there is a lack of natural resources (virgin material)
2. E-KPI taking into account embodied carbon dioxide: For such E-KPI every life cycle step should be studied, what could unavoidably take quite a time and be

intensive for a non-experienced user. This means that extraction of raw materials, process of raw materials, the production of mixtures, mixes and other products, the construction phase, the maintenance and operation of the road, and the disposal/reuse of at the end of the life cycle should be assessed.

6 CONCLUSION

The EVITA project is still on progress. Developing new Environmental Key Performance Indicators (E-KPIs) requires to clearly identifying what are the expectations of road stakeholders which felt by environment. This task was completed by the beginning of the project. Then, a review of existing E-KPIS pointed out that there are not so many available indicators in this domain. This situation is calling for the development of new E-KPIS. This work is under progress in EVITA, starting by considering the different families of expectations (reduction of noise, of air and water pollution, of non renewable resources consumption…), and for each of them, the different specifications that must be considered. The next steps of EVITA are to build the KPIs on the basis of these considerations and to propose a general framework for their implementation.

The assessment of the road infrastructure assets from the environmental point of view becomes more and more importance for the different types of stakeholders, which are affected especially by negative impacts of the traffic. It is important for a holistic, future oriented asset management approach to assess the environmental situation on an objective base using uniform E-KPIs. Nevertheless, there is still a learning process in the road administrations to speak not only from sustainability but to take over and improve the results of (research) projects like EVITA into practice. It is the duty of all of us to hand over a liveable habitat to the next generations and EVITA can be seen as one step on this important way.

REFERENCES

European Union (2002). Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, vol. L. p. 12-26.

Kephalopoulos S., Anfosso-Lédée F. (2010). Common NOise ASSessment MethOdS in EU (CNOSSOS-EU) - To be used by the EU Member States for strategic noise mapping after adoption as specified in the Directive 2002/49/EC. *JRC-IHCP, Draft JRC Reference Report*.

Lepert Ph., Geem C. et al. (2011). High Level Management Indicators. *Report of PIARC D1 Committee, Sub-committee D1.2. PIARC*. Paris.

Leport JP. Base de données sur les matériaux routiers non conventionnels – Mieux partager pour le plaisir d'OFRIR, *Recyclage et Valorisation*, n° 2, Septembre

Litzka J., Leben B. La Torre F., Weninger-Vycudil A.,Lurdes Antunes M., Kokot D, Mladenovic G., Brittain S., Viner H. (2008). The Way Forward for Pavement Performance Indicators Across Europe. *COST Action 354 Performance Indicators for Road Pavements Final Report, COST Office, Brussels and FSV – Austrian Transportation Research Association.* Vienna, Austria.

Miedema H.M.E. and Oudshoorn C.G.M. (2001). Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals. *Environmental Health Perspectives, vol. 109, no. 4, p. 409-416.*

Ventura & al (2004). Comparaison environnementale de couche de liaison de chaussées recyclées à différents taux par la méthode d'analyse du cycle de vie, *Bulletin des Laboratoires des Ponts et Chaussées*, n° 250 – 251, réf. 4527

WHO-JRC (2011). Burden of disease from environmental noise - Quantification of healthy life years lost in Europe. *World Health Organization - Regional Office for Europe*.