

# **DEVELOPMENT OF CROSS ASSET MANAGEMENT PROCEDURES ENR-PROJECT PROCROSS**

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## **ABSTRACT**

In 2010 the trans-national funded ERA-NET Road (ENR) project “PROCROSS - Development of Procedures for Cross Asset Management Optimisation” started to develop optimized procedures for cross asset management of the total road infrastructure (including all sub-assets like pavements, structures, road furniture, etc.). The project aims at a recommendation for a holistic road asset scheme to balance the maintenance expectations of different sub-assets and stakeholders.

This is somehow different to the traditional approach in asset management where monitoring and measurement data are used to assess condition levels for each sub-asset in the road transport system more or less separately. Overall life-cycle costs/performance and asset values are of secondary order within many actual procedures.

The extension in a more proactive and holistic asset management approach considers all influencing parameters (e.g. age, environment, materials, deterioration processes, loadings, maintenance policies, etc.) and impacts from a more practical and applicable point of view. Only this enables combining different sub-assets (e.g. pavements, tunnels, bridges, culverts, walls, noise barriers, variable message signs, drainage systems, etc.) through experience and good practice into a combined cross asset framework. Furthermore, it includes impact assessment of condition and measures on the overall network value.

The main benefit of such a holistic road asset scheme is on the one hand the saving of monetary and non-monetary resources and on the other hand the minimizing of negative impacts from socio-economic, technical and environmental points of view.

## **1 INTRODUCTION**

In the last 10 years a sizable number of National Road Administrations (NRA) in Europe and around the world investigated how different requirements for various assets (pavements, structures, equipment, etc.) can be brought together into a “holistic” asset management framework.

The main objective in this approach is organising asset management from a “holistic” point of view including all sub-assets in order to increase availability, reduce environmental impacts, and optimise cost-effectiveness. The ERANET Road project “Maintenance Backlog – Estimation and Use”, identified that in the context of maintenance funds procurement, the different sub-assets are more competitors than partners and coordinated maintenance activities are the minority (Weninger-Vycudil et al., 2009). The expectations of different stakeholders are taken into consideration, if at all, at the lowest acceptable level. Furthermore it is a fact that uncoordinated maintenance activities on highly sensitive road infrastructure networks are from a society’s point of view inefficient and cause negative impacts on different affected parties and of course on the environment. Different stakeholders are affected on the short-, medium- and long-term by unbalanced maintenance policies (e.g. a bridge rehabilitation in 2009 and surface treatment in 2010). Thus, one of the key tasks in the asset management process of the total road infrastructure is an improved and finally optimized coordination of all maintenance activities on the different sub-assets according to the expectations and requirements of road users, road operators, road owners and other affected parties. It is a complex process which needs flexible and adaptable methods, the experience from the road owners and operators and a clear and straight forward definition of the stakeholders’ requirements.

## 2 OBJECTIVES OF THE PROCROSS PROJECT

The main objective of the ERANET Road project PROCROSS is a comprehensive investigation on cross asset management in Europe and the recommendation of possible cross asset management procedures, which can be used for road administration as a holistic asset management framework.

The used methods are interviews and workshops organised by the PROCROSS partners. They cover the current status in cross asset management in Europe, monitoring and management requirements, identification of barriers and gaps in order to finally derive a cross asset management. Achieving the project goals and objectives requires a close cooperation between the PROCROSS Consortium and the European Road Administrations. Thus, the whole project will be based on an intensified dialogue approach between interested European Road Administrations and the Consortium in the form of workshops, interviews and discussions.

The dialogue approach will focus on the following main issues in cross asset management:

- Identifying best practice of asset management processes and understanding cross asset interdependencies and costs/values to evaluate impact of maintenance activities on the different sub-assets
- Deducing monitoring requirements from road authority’s needs (top-down approach) to collect the most important key performance indicators (KPIs)
- Development of procedures for cross asset optimisation with consideration of the expectations and requirements of the different stakeholders
- Analysing efficiency and applicability of the proposed procedures for implementation

## 3 BASIS AND REQUIREMENTS

### 3.1 Stakeholder Requirements

Asset management of the road infrastructure requires road managers and authorities to understand and address the needs and expectations of different stakeholders, which directly or

indirectly interact or are affected by the system. Stakeholders can be internal (from within the organisation) and external (outside the organisation). For road administrations, based on the above definitions, key external stakeholders therefore include owners (generally government and its agencies), suppliers, and the community from which it draws resources and customers (e.g. tax payers, users and those affected by the networks). So, most of the European NRAs are aware of their stakeholders. For some of them, regular contacts and meetings provide sufficient insight into requirements. For others, regular surveys (e.g. customer satisfaction) aid in determining the requirements (EXPECT, 2011). The main identified aspects concerning the road users, including motorists, heavy goods vehicle drivers, motorcyclists, cyclists, passengers and pedestrians in these surveys were ride quality, safety and level of service (i.e. availability, travel time reliability).

The aim of this investigation within PROCROSS is to understand stakeholders' expectations and perceptions in the road transport system. This provides input for road administrations to establish service levels and, finally, effectively incorporate them within the cross asset management process to meet financial, environmental and social requirements. In PROCROSS it was decided to group the stakeholder requirements into the following main areas:

- Safety
- Costs
- Environment
- Customer Satisfaction (incl. Availability)

## 3.2 Definitions

Beside the definition of the different stakeholder requirements it is important to identify common definitions. The following definitions are taken from the PROCROSS project (Deix et al., 2011) and are based on respective literature (COST354, 2008) and discussions within the technical advisory board (TAB) of the project. The following definitions must be understood as a common “language” within the project:

**Total road infrastructure asset:**

The total road infrastructure asset is the comprehensive term of all single assets (pavements, bridges, tunnels, culverts etc.) of the road infrastructure, which are necessary to operate a road under given requirements and pre-conditions (safety, comfort, environment etc.). The assets can be directly linked to the road or can be an independent part of this infrastructure. In the context of this project those assets, which are independent parts of the road will not be taken into consideration.

**Asset (also single asset, sub-asset):**

The term asset will be used to describe elements and/or components of the total road infrastructure asset (see definition above). A single asset can consist of different sub-elements or components, e.g. a bridge consist of the superstructure, edge beams, expansion joint etc., which are sub-elements of the bridge. Furthermore, it is possible to group different single assets from a more general point of view, e.g. bridges, tunnels, culverts, etc. may be collectively grouped as engineering structures, whilst road signs, guard rails, lighting may be collectively grouped as road furniture.

**Stakeholder:**

In the context of this project, stakeholders are defined as a specific or general group of

people which are directly or indirectly affected by the planning, construction, operation and maintenance etc. of the total road infrastructure asset. According to the actual PIARC-definitions (PIARC dictionary, 2011) the stakeholders can be categorised into users, owners, operators, neighbours, financing body and finally the society.

#### Asset Management

Asset management is the comprehensive term to describe all management activities on one or more assets of the total road infrastructure asset. It refers primarily to maintenance and operation activities but also to improvement and extension of existing assets.

#### Cross Asset Management:

Cross asset management is the combination of management tasks and activities over different assets of the total road infrastructure asset within a pre-defined management process. These tasks and activities can to various degrees have technical, economic, strategic and environmental objectives/considerations.

**Performance Indicator:** Performance indicator is a comprehensive term indicating the condition of the total road infrastructure asset. It can be expressed in the form of a technical parameter and/or in the form of an index (dimensionless).

- **Single Performance Indicator:** A single performance indicator is a dimensional or dimensionless number related to only one technical characteristic of an asset, sub-asset or the total road infrastructure asset, indicating the condition of that characteristic.
- **Combined Performance Indicator:** A combined performance indicator is a dimensional or dimensionless number related to two or more different characteristics of an asset, sub-asset or the total road infrastructure asset.
- **General Performance Indicator:** A general performance indicator is a mathematical combination of single and/or combined indicators which describe the a single asset or the total road infrastructure asset condition concerning different aspects like safety, environment, etc. (also called Global Performance Indicator)

### 3.3 Monitoring and Needs in the Management Process

Beside the definition of terms and the discussion of requirements a main focus of PROCROSS is the monitoring of information and the necessity for measurable indicators in a management process.

In common practice each single group of assets is measured, monitored and analysed to be managed individually. For this purpose, specific asset management systems, like pavement management system (PMS), bridge management system (BMS), etc. were developed. Those systems enable a selection of appropriate maintenance solutions/strategies by using different analysis methods (e.g. prioritization, life cycle analysis (LCA), life cycle cost analysis (LCCA), etc.). The method to be used to define a recommended maintenance treatment is strongly dependent on the availability of technical data and the predictability of those characteristics, which describe the deterioration of the asset or elements. But the separation of asset management in different sub-management systems (often held under the responsibility of different management departments) might be seen as the source for all difficulties in identifying appropriate cross asset management methods. However, the fact these indicators

for each asset of the total infrastructure are available helps in setting up a cross asset management system.

## 4 CROSS ASSET MANAGEMENT PROCEDURES

### 4.1 Categorization of Approaches

Based on the investigations and the discussion within the TAB different approaches of cross asset management could be found and finally categorized into two main groups. In general PROCROSS distinguishes between two methods of cross asset management optimisation:

1. Bottom-up approach
2. Top-down approach

Both approaches are valid and consistent in finding an optimum solution based on the preconditions (i.e. strategic requirements, regulatory and legal framework). The difference is merely to be seen in the way the optimum solution is identified. The two approaches are used to visualize the different concept and to help road operators and road authorities identifying the appropriate concept fitting their requirements and prerequisites. The authors assume that these appropriate concepts are merely located in between the bottom-up and top-down approach.

### 4.2 Bottom-up Approach

The bottom-up approach is strongly influenced by the technical assessment of individual groups of assets. Pre-defined technical requirements or thresholds are the basis for the recommended maintenance activities on each single sub-asset or element to be taken into consideration. Usually, each single group of assets is analyzed individually by specific management systems. Those systems enable a selection of appropriate maintenance strategies by using different analysis methods under a certain number of given preconditions. For finding an optimum solution, the preconditions (set by the NRA or the road operator) must be known and can be of monetary or non-monetary nature (e.g. available budget for a single group of assets over a certain time period). The cross asset management process is usually not carried out within this level of application, but the results can be used as a basis for the following process of cross asset “coordination”. In many countries around the globe the bottom-up process is well established and strongly supported by sophisticated management tools. Many NRAs are organized according to asset related tasks with asset specific management processes in place, so this approach fits very well for these administrations.

The results of the individual asset assessments are the basis for the definition of maintenance projects across different types of road assets, where technical and economic key performance indicators are being used to describe the effects of the measures. Of course, the process of cross asset coordination brings in the strategic targets (see chapter 3 Stakeholder Requirements) but influences strongly the “optimised” results of single asset assessment. This means that the optimal maintenance solution of the single groups of assets has to be changed often in the coordination process. The consequence is that the recommended construction program of a single group of assets (after coordination) does not match the single optimum solution anymore. The advantage of the bottom-up approach is a comprehensible technical assessment of single assets. The disadvantage can be seen in the rudimentary consideration of those requirements, which are cross asset related and need a foresighted adjustment between the different single groups of assets from the beginning.

### 4.3 Top-down Approach

In contrast to the above-mentioned bottom-up approach, this form of resource allocation is based on a central decision which deals with infrastructure on a network level. As infrastructure maintenance of existing assets in Europe consumes a considerable part of road operators' budgets significant savings can be achieved through the flexibility a collective pot for the total road infrastructure rather than on an asset by asset basis.

The decisions involved in a top-down approach require a comprehensive understanding of the overall state of the network. Road administrations would allocate certain resources to certain assets with the aim of maintaining or improving their condition, thus producing an overall standard of infrastructure that corresponds to their desired or feasible target. The implementation of such an approach is highly dependent on how the road administration themselves function: In some countries each group of assets (pavements, bridges, tunnels etc.) is managed by a different department who compete for maintenance resources. In other countries, infrastructure management decisions are taken on a regional basis, where sub-assets within the same area are treated collectively, whereas other countries might have a central administration, which greatly facilitates fund allocation with respect to achieving a uniform objective/strategy across the country. Irrespective of how road authorities are structured, the essence of a centralized fund designation is that decisions are made in the pursuit of a strategic target on network-level, rather than dealing with individual assets and how to optimally maintain them within their respective life-cycle. Top-down decisions are subsequently made based on strategic requirements.

An example of such an approach is detailed in the work of Mild and Salo (2009), where a decision model was developed for the Finnish Road Administration (Finnra) with the aim of providing a systematic decision tool that permits fund allocation under the consideration of various objectives. The method explained by Mild and Salo (2009) goes beyond a mere cost minimization tool, as it aims to provide a transparent approach for subjective preferences in resource sharing. The evaluation criteria mentioned therein are road safety, asset value preservation, customer satisfaction and environmental aspects. These are in good agreement with the factors contributing to the so-called global performance indicator in COST action 354 (2008), where indices for safety, comfort, structure and environment are used to describe the overall network and to identify deficiencies on the network level. Despite the report's focus on pavements, the idea can be expanded to other sub-assets of the total road infrastructure. Regardless of whether a top-down approach is implemented on a regional, national or even European level, the maintenance strategy arising from a central resource allocation is the result of subjectively defined guidelines or minimum requirements, such as prescribed safety standards, acceptable environmental effects and desired customer satisfaction. These targets are subject to certain boundary conditions (e.g. restricted funding) and are usually a multivariate function where each variable has an arbitrarily assigned weighting factor that depends on whether the problem is approached from the point of view of the road operator, the user or any of the other stakeholders mentioned above.

### 4.4 Recommended Cross Asset Management Optimisation Procedure

Both approaches, bottom-up and top-down, reflect the different requirements from the object (technical) level but also from the strategic level. Thus, it is recommended to combine the two management processes into one procedure, where the optimisation will be based in the middle as the combining element (see Figure 1). Of course, to enable a cross asset management optimisation corresponding key performance indicators (KPIs) must be defined on the strategic level but also on object (technical) level.

The difficulty for such an approach could be seen on the strategic level within the transformation of strategic targets and requirements into strategic KPIs, which could be used

as numerical value within the optimisation process. Not all targets and requirements enable such a transformation, so that indirect indicators must be applied for different aspects (e.g. definition of riding comfort in the form of vehicle operating costs (VOC), definition of traffic safety in form of accident risk or accident costs).

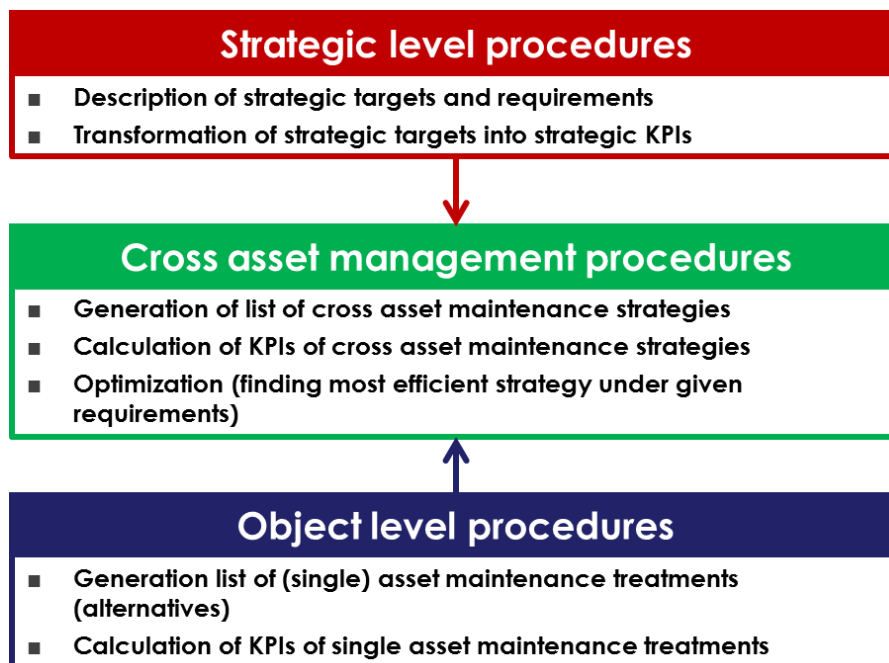


Figure 1: Cross asset management procedures within the asset management approach

On the other side (top-down), the effect of maintenance treatments must be expressed by using compatible KPIs well. Only this compatibility enables an optimisation approach and a communication between the object (technical) level and the strategic targets. The decisive factor for such an approach on the object level is on the one hand the availability of data (for the different type of assets) and on the other hand the availability of mathematical relationships between the effects of the measures and the respective KPIs (e.g. effect of a maintenance strategy on accident risk or on VOC over a certain time period).

As already mentioned the optimisation should combine both, the strategic level and the object (technical) level. In general the cross asset optimisation comprise the following procedures

- Based on the list of (single) asset maintenance treatments different maintenance strategies (combination of different maintenance activities on different assets within a given time period) have to be defined (automated, semi-automated or manually)
- The target related KPIs have to be calculated for the cross asset treatments (coordinated maintenance alternatives), where the effects should be assessed over a longer time period (life-cycle approach)
- Finally, within the mathematical optimization the most efficient maintenance strategy over the whole network should be found (e.g. finding the most efficient cross asset treatments with the lowest VOC under budgetary constraints).

The output of such a process is a list of recommended (most efficient) cross asset maintenance treatments on the investigated network under the pre-defined strategic targets. This can be used on the one hand as a basis for the assessment of the strategic targets on the

strategic level and on the other hand as a basis for the development of a coordinated short- to medium-term maintenance program.

## 5 CONCLUSION

The overall objective of PROCROSS is to develop a framework for cross asset management optimisation considering all aspects in asset management (i.e. stakeholder requirements, monitoring and management needs, strategic objectives, cost and value consideration, life cycle oriented approach, environmental aspects). Based on the investigations and the discussion within the TAB different approaches were assessed according to strategic and technical requirements but also to the needs of the different stakeholders. The recommended bottom-up and top-down approach assures large coverage, applicability and relevance for various European asset managers being either early adopters or catching-up in cross asset management.

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