PROCROSS

Development of Procedures for Cross Asset Management Optimisation

Effective monitoring of road infrastructure assets

Deliverable No. 2

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Executive summary

Within Deliverable 2 “Effective monitoring of road infrastructure assets” the governing factors for cross asset management were collected and assessed in close cooperation with European road administrations. This deliverable covers the result of the 2nd PROCROSS TAB workshop and expert interviews, carried out with Germany, The Netherlands, United Kingdoms and Finland.

The collected information of the workshop and the interviews were assessed, compared and discussed with the road administration authorities and the partners of the consortium. Beside the list of indicators to be used for asset management on object level the main focus of the activities were also on the indicators to be used for cross asset management optimization procedures on both technical and strategic level. Especially the different approaches could be categorized in “top-down”, “bottom-up” and “top-down in combination with bottom up” cross asset management processes.

The conclusions of the tasks to be performed are on the one hand in the understanding of different cross asset management approaches including the definition of strategies, needs and requirements and on the other hand the definition, use and common understanding of performance indicators on technical and strategic level in relation to the organizational structures of the road administration authorities.

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1 Introduction

1.1 PROCROSS overview and objectives

One of the key tasks in the asset management process is an improved and optimised coordination of all maintenance activities on the different 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 experiences from the road owners and operators and a clear definition of the stakeholders' requirements.

Description

The main objective of the project is the development of optimised procedures for cross asset management of the total road infrastructure (including all 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 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 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.

An asset management approach should consider all influencing parameters *(e.g. age, environment, materials, deterioration processes, loadings, network/route importance, risk, maintenance policies, etc.)* and impacts from a more practical point of view. Different assets (*e.g. pavements, tunnels, bridges, culverts, walls, noise barriers, variable message signs, drainage systems, etc.)* through experience and good practice are proposed into a combined cross asset framework.

The main benefit of introducing such a holistic road asset scheme is to save monetary and non-monetary resources and minimising of negative impacts from socio-economic, technical and environmental points of view.

Expected results

The result of the PROCROSS project is a holistic approach for the cross asset optimisation of maintenance activities on the total road infrastructure. Based on a state of the art investigation, which is carried out in close cooperation with European road administrations, the procedures enable to combine maintenance activities on different assets and thus to reduce all negative impacts and effects to road users and other affected parties under different requirements and expectations.

The results cover an extensive field of application concerning:

- A survey of the State-of-the-Art to find out good practice in cross asset management optimisation;
- Benchmarking of cross asset management optimisation procedures;
- Improve efficiency of asset management of the total road infrastructure;
- Assess maintenance activities from different stakeholders' expectations and requirements;
- Support of the decision makers to underline the necessity of maintenance activities from a holistic point of view;
- Provide a basis for the implementation of cross asset management optimisation procedures in the form of the Final report "The Procedures for Cross Asset Management Optimisation".

1.2 Method

To achieve the project goals and objectives a close cooperation between the Consortium and the European Road Administrations is essential. Thus, the whole project is 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 focuses on the following main tasks of PROCROSS:

- **Identifying best practice** of asset management processes and understanding **cross asset interdependencies** and costs/values to evaluate the impact of maintenance activities on the different assets;
- Deducing **monitoring requirement**s from road authorities' 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.**

For this dialogue a separate Technical Advisory Board (TAB) was established and chaired by an experienced Technical Advisor (Prof. J. Litzka). The European Road Administration of the PEB member countries and other selected countries are invited to participate on this board and to provide the Consortium with the necessary information.

With regard to the realising the objectives of PROCROSS four dialogues are carried out by the Consortium in mutual agreement with the client and the Technical Advisor of the TAB. *Dialogue 1 - Identification of best practice, Dialogue 2 - Monitoring requirements, Dialogue 3 - Development of cross asset management optimisation procedures, Dialogue 4 – Implementation guide* support the exchange of experiences and expectations.

The first Dialogue 1 - Identification of best practice delivered a Workshop focussing on:

- Existing cross asset procedures
- Impact of maintenance activities on different assets
- Stakeholders' requirements and expectations for cross asset optimisation
- Interviews focussing on cross asset interdependencies

The workshop took place in Ljubljana on the 9th and 10th of March 2011 and provided the basis for this first deliverable (*Good practice in Cross Asset Management Optimisation, Deliverable No. 1*).

The second *Dialogue 2 - Monitoring requirements* delivered a Workshop and interviews focussing on:

- Presentation of results of Dialogue 1
- Key Performance Indicators for cross asset optimisation
- Effective monitoring of road infrastructure asset

The workshop was held on the 6th and 7th of September 2011 in Vienna at AIT. The interviews were organised in the first quarter of 2012 with specific targeted countries and road authorities to feed additional input into this Deliverable D2: Effective monitoring of road infrastructure assets.

1.3 Definitions

For the assessment of existing and new or advanced cross-asset management procedures it is important to define those terms which will be mostly used within this project. The basis for the following definitions are on the one hand the actual respective literature (e.g. COST354, 2008) and on the other hand the discussions within the Project Team and during the

Workshops.

Total Road Infrastructure Asset

The *Total Road Infrastructure Asset* is the comprehensive term of all 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

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. bridge consist of the superstructure, edge beams, expansion joint etc., which are sub-elements of the asset bridge. Furthermore it is possible to group different 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 PIARC-definitions the *Stakeholders* can be categorised into the following groups:

- Users
- Owners
- Operators
- Neighbours
- Financing body
- Society

Asset Management

Asset Management is the comprehensive term to describe all management activities on one or more *Assets* on 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, 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, that indicates the condition of all the characteristics involved.

General Performance Indicator

A *General Performance Indicator* is a mathematical combination of *Single and/or Combined Indicators* which describe the asset condition concerning different aspects like safety, environment, etc. (also called *Global Performance Indicator*)

2 TAB workshop: Effective monitoring of road infrastructure assets

The 2nd TAB workshop: Effective monitoring of road infrastructure assets was organised on the 7th and 8th of September 2011 at AIT in Giefinggasse 2, 1210 Vienna, AUSTRIA. The workshop was organised as a 2 days' workshop.

The aim of this workshop was to elaborate answers to the questions:

1. What indicators are used for asset management in the different countries?
2. Which indicators or parameters are monitored or measured for different road categories (motorway, national roads, secondary roads, rural roads)
3. What is the objective of cross asset management?
4. How is cross asset management implemented today in the different TAB member countries?

The first two questions were elaborated in a group work on flipcharts and hand-outs with follow-up discussions and question 3 and 4 were discussed in the plenary (see workshop hand-outs ANNNEX B).

2.1 Workshop participants

The participation at the second PROCROSS TAB workshop was higher than compared to the first workshop in Ljubljana. The TAB representatives covered a large part of Europe (DEN, SUI, BEL, SWE, GER, NOR, AUT, UK).

TAB members (participating)

ASFiNAG	Gerhard Eberl, AT
ASTRA	Luzia Seiler, CH
BASt	Roland Weber, D
VTI	Leif Sjögren, S
SRA	Ulla Ericsson, S
NPRA	Helen Riddervold, NO

AWV	Margo Briessinck, B
TNO	Willy Pelen, NL
DRD	Mikkel Bruun (ENR SRO4 PEB Chair), DK
HA	Ramesh Sinhal, UK
IGH	Sandra Skaric Palic, CRO

PROCROSS partners (participating)

AIT	Stefan Deix (Coordinator), Karoline Alten
PMS	Alfred Weninger-Vycudil
TU	Johann Litzka (Technical Advisor)
TCD	Alan O'Connor
SEP	Günther Maerschalk
ZAG	Lojze Bevc

2.2 Monitoring requirements

Analysing the results of the TAB workshop revealed the current monitoring practice. *If you can't measure it, you can't manage it*! – is a famous quote (origin unknown) often used to describe the necessity for measurable indicators in a management process. And this holds valid for asset management in general and specifically for cross asset management in particular. In common practice each single group of assets is measured, monitored and analysed to be managed individually. For this purpose specific management systems, like Pavement Management System (PMS), Bridge Management System (BMS), etc. were developed. Those systems enable 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 into 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 that indicators for each asset of the total infrastructure are available aids the establishment of a cross asset management system.

Several performance indicators and their usage in different countries according to question 1 and question 2 build the basis for assessing the assets and are shown in tables 1 to 4.

Table 1: Pavement: number of countries using performance indicators related to road class (nine participants)

Road class	Longitudinal evenness	Transverse evenness	Skid Resistance / texture	Structural condition, cracking, bearing capacity	Others
Motorway	9	9	9	8	3
National	8	8	9	8	3
Secondary	6	6	4	5	1
Rural	1	2	0	1	1

The results in table 1 show that performance indicators in pavement management for motorways are used in all of the countries which participated in the workshop. Almost similar results as for motorways could be found on the national roads. About half of the participating countries use some performance indicators also for the secondary roads however only a few do so for the rural roads.

Other performance indicators, which are also used in assessing the pavement are socioeconomic indicators (DK) surface characteristics related to noise (CPX) (CH) and edge deterioration (UK).

Table 2: Engineering structures: number of countries using performance indicators related to road class (ten participants)

Road class	Corrosion	Cracks	Deformation / Stiffness	Safety index β; R	Serviceability
Motorway	10	10	9	5	6
National	9	9	9	5	6
Secondary	5	6	4	3	4
Rural	2	2	1	0	1

The results in table 2 for engineering structures show that performance indicators are used for structures management on motorways and national roads in almost all countries which participated at the workshop. About half of the participating countries also use performance indicators for engineering structures on secondary roads. Only a few counties are using some performance indicators for rural roads.

Serviceability performance indicators for structures in relation to the road class are given in table 3.

Table 3: Engineering structures: number of countries using serviceability performance indicators related to road class (nine participants)

Road class	Bearing Capacity	Risk Analysis	Loading Assessment	Durability
Motorway	3	1	1	1
National	3	1	1	1
Secondary	2	1	1	0
Rural	0	0	1	0

Table 3 shows that the majority of serviceability performance indicators are related to the bearing capacity of the engineering structures. Nevertheless, in comparison to the other indicators, only a few countries are using indicators for the assessment of the serviceability.

Table 4: Road furniture: number of countries using performance indicators related to road class (9 participants)

Road class	Stability	Serviceability	Reflectivity	Others
Motorway	5	6	3	2
National	4	4	2	2
Secondary	3	3	2	1
Rural	0	1	0	1

The results in table 4 show that performance indicators for the assessment of the furniture are not as extensively used as for engineering structures and pavements on the main roads (i.e. motorways and national roads). The reason for this is considered to be that condition assessment of road furniture is in general not a decisive element in asset management and therefore it is not generally a part of cross-asset management procedures.

Table 5 shows some other performance indicators, which are used for road furniture in some of the countries who participated at the workshop.

Table 5: Road furniture: number of countries using other performance indicators related to road class

Road class	Safety	Environmental value	Lightning	Drainage
Motorway	1	1	1	1
National	0	0	1	1
Secondary	0	0	1	1
Rural	0	0	1	1

3 Understanding cross-asset management

Based on the discussions within the workshops PROCROSS distinguishes between two methods of cross asset management optimisation in general:

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 concepts and to help road operators and road authorities in 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.

3.1.1 Bottom-up Approach

The Bottom-Up-approach is strongly influenced by the technical assessment of individual groups of assets (object level). Pre-defined technical requirements or thresholds and target-values are the basis for the recommended maintenance activities on each single asset or sub-element to be taken into consideration. Usually, each single group of assets is analysed individually by specific management systems. Those systems facilitate the selection of appropriate maintenance solutions by using different analysis methods under a certain number of given, and clearly defined, 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, so that this approach fits to asset specific management processes.

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 necessarily. 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.

3.1.2 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. Seeing as the upkeep of existing assets in Europe consumes a considerable part of road operators' budgets compared to the amount spent on network expansion, significant savings can be achieved if road infrastructure is treated collectively 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 agencies 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 agencies themselves function: each group of assets (pavements, bridges, tunnels etc.) may, for example, be managed by different departments who compete for resources from the same pot, while some countries manage infrastructure on a regional basis, where assets within the same area are treated collectively, whereas others 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 defined in COST Action 354 (2008), where indices for safety, comfort, structure and environment are used to describe the overall network and to identify potentially weaker sections. Despite the report's focus on pavements, the idea can be expanded to other 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 Interviews

4.1 Objectives of the interviews and organisation

One of the critical factors for the success of PROCROSS is understanding cross asset management and cross asset management procedures as used in practice. As described in the objectives of the project the procedures should be applicable for different road administrations within Europe and should provide a basis for a more holistic asset management approach.

Based on the investigations within the workshops and the review of the actual literature it has been decided in mutual agreement with the PEB to go more in detail about practical applications and to perform interviews with pre-selected road administrations. The main

objective of these interviews is to get a better understanding of how cross asset management works in Europe and how strategic targets and requirements will be achieved on different levels of application (see interview guide ANNNEX A).

In the context of the preparation of the interviews a questionnaire was designed as a basis for the execution of the interviews. The questionnaire comprises five main areas of interests, which can be summarized with the following five questions:

- What strategic targets and requirement are used in the asset management process?
- How do you monitor and assess the different assets on an object (technical) level?
- How do you combine the needs on object level with the strategic targets and requirements?
- How do you combine the needs of the different assets?
- Which approach (Bottom-up, Top-down, Bottom-up and Top-down) generally fits your asset management processes?

A template of the questionnaire can be taken from the Annex A.

As already mentioned, the interviewed road administrations were pre-selected in mutual agreement with the participants of the workshops and the PEB. In total the following 4 European road administrations have been interviewed in March 2012:

1. German Federal Ministry of Transport, Building and Urban Affairs, Germany
2. Rijkswaterstaat, The Netherlands
3. Highways Agency, United Kingdom
4. Finnish Transport Agency, Finland

4.2 Summary of the interviews

The following sub-chapters contain a summary of the interviews performed with the aforementioned road agencies. It has to be stressed, that only those road networks, which are in the direct responsibility of the respective road administration, were included in the interviews. As a result the main focus became the high-level road network.

4.2.1 Germany

The interview in Germany was carried out with the German Federal Ministry of Transport, Building and Urban Affairs (BMVBS). The interview partner was Mr. Gregor Schroeder.

4.2.1.1 Organisation and road network

The BMVBS is responsible for financing and maintenance of the federal trunk road network in Germany. The asset management procedures are applied by the states on behalf of the Federal Republic (execution and administrative issues of maintenance, defined by constitutional law). Thus, the 16 federal states are partners in the context of maintenance of the federal trunk road network. At state level there are usually 3 administrative levels in place:

- State ministry
- Intermediate authority (state authority)
- Building authority

The federal trunk road network in the responsibility of BMVBS consists of the following roads:

- Motorways: 12’800km
- Federal highways: 38’000km

4.2.1.2 Strategic targets and requirements

The BMVBS defines strategic targets in the form of a focused condition distribution, which is based on representative (technical) performance indicators. The distribution is calculated based on LCA, object specific inventory and condition data coming from the technical (object) level assessment of the different assets. Based on this focused condition distribution the BMVBS estimates the necessary maintenance budget for the different assets over a certain time period. This budget is the monetary framework for the budget distribution to the states and the different assets. The maintenance budget, which is necessary to achieve the pre-defined condition distribution, is stipulated in the Federal Transport Infrastructure Plan (Bundesverkehrswegeplan) which must be adopted by the Federal Parliament.

For the definition of the focused condition distribution representative (non-monetary) technical indicators (indices) describing the safety and the structural condition of the assets the following are employed:

- Pavement:
  - Functional index
  - Structural index
- Engineering structures:
  - Stability
  - Safety
  - Durability

The definition of strategic targets according to the availability (user cost model) is under research but not ready for use in the context of strategic target definitions at the moment.

4.2.1.3 Monitoring and assessment

The different assets (pavement, bridges, tunnels etc.) will be monitored or inspected in different intervals and to different extents based on national guidelines and standards (e.g. DIN 1076). The framework and procedures for the monitoring and assessment of the different assets can be described as follows:

- **Pavements**: On the pavements high speed condition measurements will be carried out every 4 years under supervision of BASt (Federal road research institution) and assessed on a unified procedure. Pavement performance indicators describe the characteristics of the road surface and the structural condition by using single indicators (rutting, skid resistance, longitudinal evenness, cracking, patching on asphalt pavements, corner breaks and joint damages on rigid pavements), combined indicators (functional, structural) and total condition index, as well as pavement design and age.
- **Engineering structures**: The assessment of the engineering structures, which are categorized into bridges, gantries, tunnels and trough structures, retaining structures, noise barriers, etc., refers to stability, safety and durability. Within visual inspections (main inspection - every 6 years; interim inspection - every 3 years; special inspections) distresses of the single components will be collected and summarized to groups and finally to a total condition index.
- **Other assets**: Assets, like drainage, soil and subgrade, planting, furniture and equipment (e.g. lightning, protections systems etc.), culverts will be monitored during safety inspections only (no periodical condition survey and assessment).

4.2.1.4 Combination object level needs with the strategic targets and requirements

The strategic targets and requirements are a framework input for the technical object related planning of maintenance measures of the different types of assets on state level, where the coordination of these activities takes place. The framework of the procedure is as follows:

- The construction program (including maintenance, new construction and extensions) will be forwarded from the states to the BMVBS on a yearly base and provides the basis for the distribution of the budget.
- The distribution key of the maintenance budget to the different states is fixed by the BMVBS
- The states are free to split their allocated budget to maintenance, new construction and extensions.

Based on this procedure the combination of object level needs with the strategic targets can be seen as a two level procedure, where the BMVBS defines the budgetary framework (by using the technical input from the states) and the federal states are responsible to execute the activities according to their needs.

4.2.1.5 Combination of needs of different assets (cross asset management)

As already mentioned, the combination of needs of different assets will be carried out on state level only. At the moment the combination is based on engineering judgment, where advanced visualization methods (e.g. strip maps showing the condition information and the recommended maintenance treatments of the different assets) will be used as tools for the engineers to get a holistic view of the maintenance needs of the different assets.

There are no calculations of effects on users and other external costs, and no unified (optimization) algorithm, which combines different treatments on an objective basis. The actual research activities on external costs could be a possible basis for such an optimization algorithm in the future.

4.2.1.6 Categorization of cross asset management approach

The current approach of cross asset management procedures can be categorized as ***Top-down and Bottom-up solution*** with the following framework conditions:

- The technical (object) level data and information (condition, inventory, etc.) are a basis for the strategic targets, defined in the Federal Transport Infrastructure Plan
- Finally, strategic targets are used as input for maintenance planning on state level
- Fixed distribution key for budget distribution to federal states
- Detailed calculation results of financial maintenance demand for the Federal Transport Infrastructure Plan can be used as input from the federal states for their planning
- No cross asset management on objective algorithm, which takes strategic targets directly into consideration at the moment

The whole process for the allocation of maintenance budget according to strategic requirements is a loop, where detailed, asset specific technical information will be used to generate a budgetary framework for the whole road infrastructure. Afterwards, this budgetary framework will be allocated to the states (by using a fixed key), which can be in contradiction to the basis of the strategic target to a certain extend and makes it necessary to update this process periodically.

4.2.2 The Netherlands

The interview in The Netherlands was carried out with Rijkswaterstaat. The interview partners were Mr. Jenne v.d. Velde, Mr. Bert de Wit, Mr. Max Klok, Mrs. Petra Paffen and Mr. Jasper Schavemaker.

4.2.2.1 Organisation and road network

Rijkswaterstaat is responsible for financing and maintenance of strategic highways (federal trunk road network), strategic waterways and water systems in The Netherlands. It is the executive organisation that manages the main national infrastructure facilities on behalf of the Minister and State Secretary Infrastructure and Environment.

The activities will be carried out with 10 regional departments, 5 specialized departments, 35 districts and 3 project departments.

The federal infrastructure in the responsibility of Rijkswaterstaat consists of the following assets:

- Federal highways: 3'300 km
- Waterways: 1'700 km
- Water systems: 65'250 km^2

4.2.2.2 Strategic targets and requirements

The 3 key words Costs, Performance and Risk are the key factors for the asset management procedures and for the definition of the targets and requirements. The maintenance of the assets is based on a Service Level Agreement between Rijkswaterstaat and the Ministry, which will be updated every 4 years. The objective of this agreement can be summarized under the wording "To deliver best service to the public at lowest life cycle costs, given public acceptable risk". Based on these objectives the service contracts (maintenance contracts) will be defined with the regional partners and annually updated. The role of the three different stakeholders can be defined as follows:

- Asset Owner (Ministry)
  - Future orientation of the road network
  - Framework definition (targets, risk and cost)
- Asset Manager (Rijkswaterstaat)
  - Tactical plans (investment strategy, maintenance concept, technology standard)
  - Program management (risk management, performance management)
- Service provider
  - Operations (renewal, expansions, maintenance)
  - Project management and processes

The implementation of the strategic targets and requirements is based on the 4 year asset management program and focuses on the following issues:

- Service level agreements (SLA)
- SLA cycle
- Risk based maintenance planning: RAMS (SHEEP) = reliability, availability, maintainability, safety, security, health, environment, economics, politics)

Different KPIs (e.g. congestion, skid resistance, rutting, number of fatalities, accidents, noise, etc.) will be used to assess the condition of the assets and are being defined in the SLA including thresholds for different road categories.

4.2.2.3 Monitoring and assessment

The different assets (pavement, bridges, tunnels etc.) will be monitored or inspected periodically (e.g. pavements: high speed measuring device ARAN). The output of these inspections will be used on the one hand for the assessment of SLA (gap analysis) and on the other hand for the definition of the maintenance program of the different assets by using LCC analysis (e.g. pavements: IVON-system).

4.2.2.4 Combination object level needs with the strategic targets and requirements

The combination of object level needs and the strategic requirements are based on a 3 level closed loop procedure (objectives and standards, plans, contracts), which includes a clear allocation of responsibilities and tasks within the holistic decision framework. The following Figure 1 shows this scheme schematically

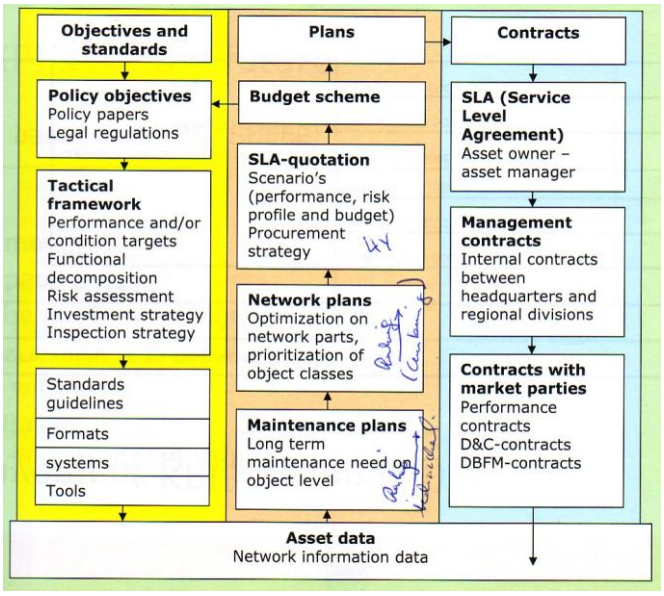

Figure 1: Asset management procedures of Rijkswaterstaat

4.2.2.5 Combination of needs of different assets (cross asset management)

The combination of maintenance needs of single assets into coordinated cross asset treatments is included in the Network Plans, which are a part of the asset management procedures (see Figure 1).

By using LCC analysis the maintenance needs will be defined on asset level and are the input for the Network Plan, which is based on system-engineering concept and consists of the following sub-procedures:

- Optimization on network parts (by regional departments)
- Unified data management for decision making process and prioritization of (combined) object classes (pavements, bridges, etc.) by using RUPS (program base for combined object class needs and prioritize to match funding sources).

4.2.2.6 Categorization of cross asset management approach

The current approach of cross asset management procedures can be categorized as ***Top-down and Bottom-up solution*** with the following framework conditions:

- SLA with Ministry (4 years) gives strategy and object level needs, which are used for prioritization
- Optimization is based on a 2 stage approach (combined object class needs, prioritization) within the Network Plan (RUPS) as a part of the of the holistic asset management procedures
- Assessment of impacts according to the importance of the road (1st step to risk based approach)

4.2.3 United Kingdom (England)

The interview in the United Kingdom (England) was carried out with the Highways Agency (HA). The interview partners were Mr. Ramesh Sinhal and Mr. Richard Abell (TRL).

4.2.3.1 Organisation and road network

Highways Agency (HA) is responsible for the operation, maintenance and improvement of motorways and trunk roads in England. It is the executive organisation that manages the main road infrastructure facilities on behalf of the Department for Transport.

The activities will be carried out with 2 directorates (network operation directorate, network services directorate) and 9 regional offices.

The federal trunk road network in the responsibility of Highways Agency consists of the following assets:

- Motorways: 3'000 km
- Other primary roads: 4'000 km

4.2.3.2 Strategic targets and requirements

The strategic targets and requirements for the Highways Agency are being defined in

- The Highways Agency's Strategic Plan 2010-15 (see Figure 2), and in the
- Business Plan 2011-12 (see Figure 2).

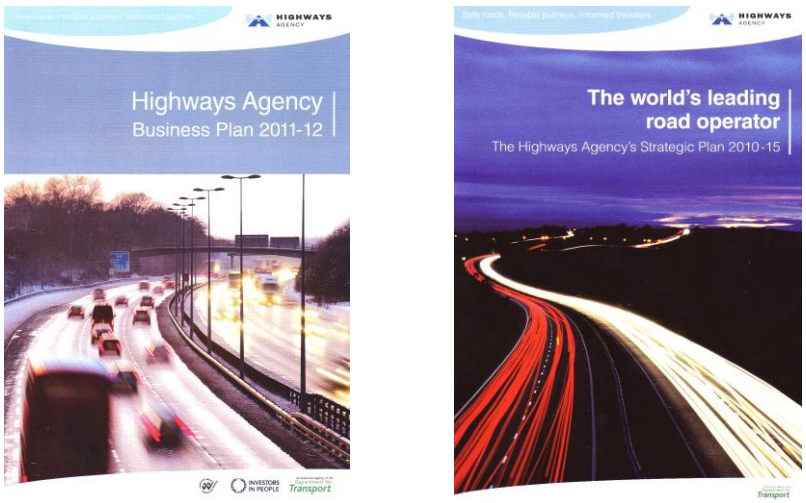

Figure 2: Strategic Plans of HA

The Strategic Plan defines the visions, goals and challenges in the context of safety, sustainability and resilience. The plan is a basis for the costumers (users) and sets the course and direction for the business for the next 5 years, translating goals into frontline delivery.

The Business Plan of the Highways Agency is a framework for the operation, maintenance and the improvement of the network according to efficiency, safety, reduction of costs, sustainability, value for money and the environment. It defines the goals and objectives in a general form, but includes a list of measures, their purpose and how often the performance should be controlled.

Within both plans no requirements according to technical (object and asset specific) indicators are defined.

4.2.3.3 Monitoring and assessment

The main assets (pavement, engineering structures, geotechnical (earthworks) and drainage) will be monitored periodically in form of high speed measurements on the pavements and in form of inspections (general – every 2 years; principal – every 6 years) for the engineering structures and other assets.

The output of the intensive monitoring are detailed information about the condition and are the basis for the definition of the maintenance needs on the different assets. The condition information will be assessed (e.g. component condition of structures will be combined to overall condition index within a scale from 0 – 100) and reported on a standardized base (e.g. pavements: percentage of sections below thresholds).

4.2.3.4 Combination object level needs with the strategic targets and requirements

The different assets will be measured according to the strategic performance individually. Approx. 400 schemes (maintenance project) define the programme for pavements, bridges, etc. Hybrid schemes try to treat more assets into one scheme.

The definition of the maintenance schemes is supported by decision support tools like Pavement Management System (HAPMS, whole life cost model; “minimize cost analysis” to hold condition of road network above the “not acceptable” condition) and Structures Management Information System (SMIS, centralized database).

This procedure provides the basis for the definition of the annual maintenance requirements.

4.2.3.5 Combination of needs of different assets (cross asset management)

The combination of maintenance needs of single assets (schemes) into coordinated cross asset treatments is mainly based on engineering judgement. The responsibility of this task is on the regional level, where the Managing Agents put the schemes together, define the work to be carried out and allocate the budget to the different single assets (pavement, structures, etc.)

4.2.3.6 Categorization of cross asset management approach

The current approach of cross asset management procedures can be categorized from a general point of view as ***Top-down and Bottom-up solution*** with the following framework conditions:

- The strategic targets and requirements are defined in the multi-year plans, which are used to measure the performance of the assets, tasks and processes. They are used as a general demand for the definition of the maintenance schemes, but do not hold exact (technical) values and targets.
- The asset management tools estimate value four money for each asset type on network level
- Each area (region) defines its own asset management plan. Based on technical information coming from condition measurement and analysis (e.g. LCA for pavements) the needs of the single assets will be defined (schemes) and brought together (engineering judgement).
- The management of the schemes will be carried out on a national basis, which enables a control according to the strategic requirements and targets

4.2.4 United Kingdom (London)

The second interview in the United Kingdom (London) was carried out with the Transport for London (TfL). The interview partner was Mr. Leigh Boswell (TfL).

4.2.4.1 Organisation and road network

The community road administration Transport for London (TfL) is responsible for the operation, maintenance and improvement of so called class “A” roads (federal trunk roads) in the greater area of London in England.

The asset management activities for roads are organized in regional/geographic entities in close cooperation with the 33 boroughs of London.

The federal trunk road network (class A roads) in the responsibility of Transport of London has a total length of approx. 510 km (carriageway length).

4.2.4.2 Strategic targets and requirements

The strategic targets and requirements for the Transport for London are being set by the Mayor of London and are being related to the public expectations according to the following topics:

- Traffic flows
- Reducing Congestion
- Safety
- Accident history

Based on the public expectations the key performance indicators for the strategic targets and requirements are on the one hand the “Level of Service” (congestion) and the “Level of risk” (skid resistance, rutting, etc.).

The value criteria are as follows:

- Safety – the risk posed to the public
- Functionality – the risk to network performance, including but not restricted to availability and reliability (overall condition)
- Environment – the risk posed to the environment
- Financial – providing WLC (whole life cost) savings considering both direct costs to TfL and indirect costs to the economy

The first three value criteria are used for scoring the risk, the last topic scores the financial requirements.

The following Figure 3 gives an overview of the Highways Asset Management System with the relationships of the different stakeholders and the process from visions, policy & objectives over strategy & planning to operations & delivery and finally ends in the benefits realization & performance measurement.

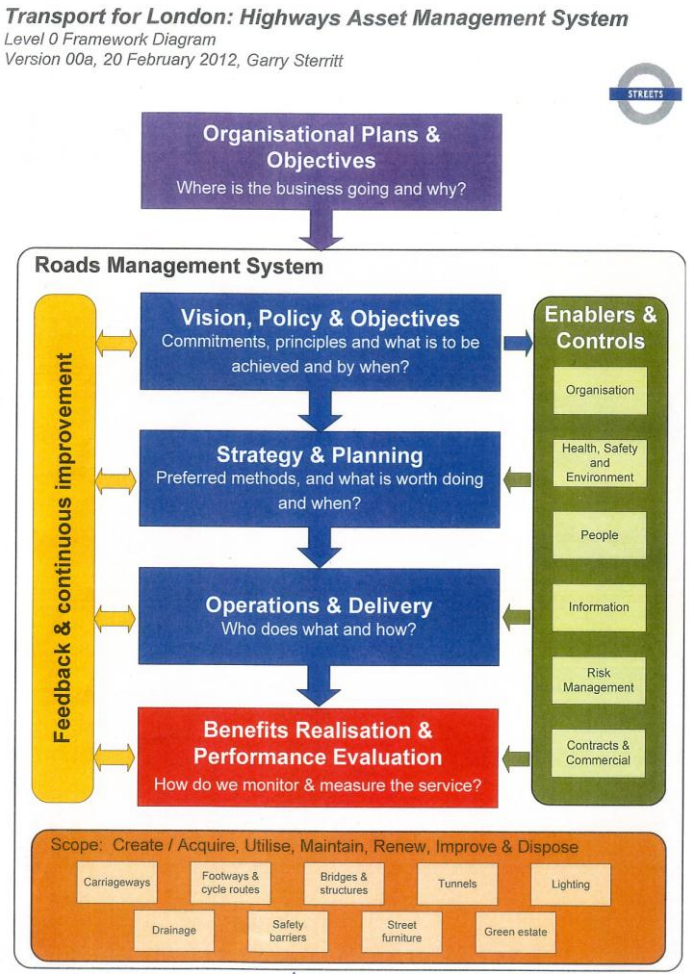

Figure 3: Highway Asset Management process at TfL

4.2.4.3 Monitoring and assessment

The main assets in the responsibility of TfL are carriageways, footways & cycle routes, bridges & structures, tunnels, lighting, drainage, safety barriers, street furniture and green estate. The carriageways and footways will be monitored as well as the engineering structures (general inspections and principal inspection).

The output of the monitoring on the carriageways and footways is defined in the NAMS-inventory and will be used in the UKPMS (state of repair, SCANNER data, and normalized longitudinal index). The different indicators will be combined for the definition of the condition.

Beside carriageways & footways and engineering structures not much data is available at the moment.

4.2.4.4 Combination object level needs with the strategic targets and requirements

The combination of object level needs with the strategic targets and requirements will be carried out in the form of risk based approach including the whole life cost (WLC). The assessment is done for each asset individually (carriageway, footway, engineering structure, etc., but not on drainage) and aims at the “State of good repair”. The output is a list of options for the different schemes for the different assets, which provides the basis for the cross asset optimization and the programme to be forwarded.

4.2.4.5 Combination of needs of different assets (cross asset management)

The combination of maintenance needs of single assets (schemes) into coordinated cross asset treatments is a risk based approach, where for each single scheme the value criteria will be used to calculate a “Risk Rating Benchmark Value” (score from 0 to 100). This value will be used for the optimized prioritization. The prioritized indicative list of schemes is the first stage in the process and is based on:

- Weighted Value Criterion (depending to the type of asset or sub-element)
- Costs based on historic rates
- Prioritized by Risk Rating Benchmark or Safety Risk Rating
- Programmed according to annual budget allocations

For the asset type prioritization / optimization of different option within a scheme the following assessment indicators will be used and calculated based on LCA:

- Value Criteria (risk rating and risk mitigation) for Safety, Functionality and Environment
- Risk Rating Benchmark
- Weighted Risk Mitigation
- Residual Risk
- Financial Indicator
- Scheme Costs
- WLC (costs)

In the following Figure 4 the program optimisation at TfL is shown schematically. The optimum bundle of the schemes is based on an cross asset optimization procedure, where the combination of different options will be assessed and finally selected according to the given requirements.

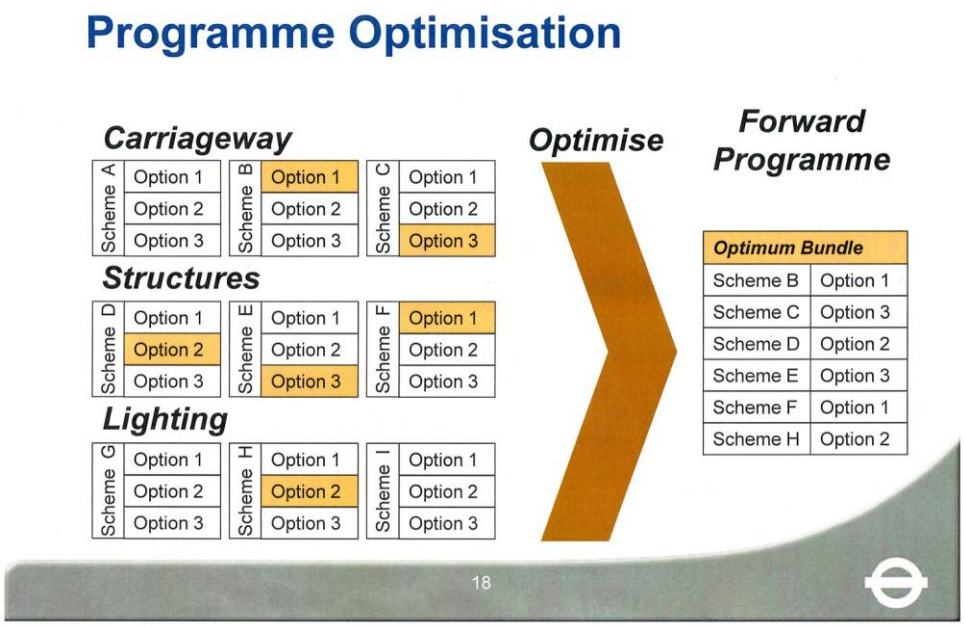

Figure 4: Program optimisation at TfL

4.2.4.6 Categorization of cross asset management approach

The current approach of cross asset management procedures can be categorized from a general point of view as ***Top-down and Bottom-up solution*** with the following framework conditions:

- The strategic targets and requirements are defined by the Mayor of London and will be expressed by different asset specific Value Criteria (Safety, Functionality and Environment) and the annual budget
- The asset management tools estimates the risk of each single scheme option and the WLC (whole life cost) as a basis for cross asset prioritization / optimization.
- The program to be forwarded takes asset specific needs and the strategic targets into consideration and tries to minimize the risk (according to the value criteria) under the given budgetary constraints.

4.2.5 Finland

The interview in Finland was carried out with the Finnish Transport Agency. The interview partner was Vesa Mannistö.

4.2.5.1 Organisation and road network

The Finnish Transport Agency, which is responsible for public road network, is a Multimodal Transport Agency for the total transport infrastructure (road, rail and waterways). It is the executive organisation that manages the Finnish transport infrastructure on behalf of the Ministry.

The activities will be carried out by a central administration in cooperation with and 9 regional offices.

The public road network in the responsibility of the Finnish Transport Agency consists of the following assets:

- Motorways: 700 km
- Other public roads: 77’500 km (therefrom 28’000 km of gravel roads)

4.2.5.2 Strategic targets and requirements

The strategic targets and requirements for the Finnish federal trunk road network (motorways and other public roads) are codified in form of a Service Agreement with the Ministry, which will be updated or upgraded on an annual base. In total 13 indicators are defined for all modes, which refer to the key factors: safety and environment, customer satisfaction, punctuality, condition and productivity (internal).

For the road infrastructure assets the following 2 indicators define the targets and requirements:

1. Proportion bad conditions of pavements
2. Proportion bad condition of engineering structures (bridges and tunnels)

These two key-performance indicators are based on a uniform classification scale, where 5 is “very good” and 1 is “very bad”. The maintenance backlog is referred to assets/ components, which are in bad condition (class 1 or 2).

Based on the given targets and requirement the priorities of the overall maintenance strategies are as follows:

- Condition of important road network (approx. 15'000 km)
- Daily maintenance and trafficability of all roads
- Condition of critical engineering structures (bridges and tunnels)

With regard to the different needs of the different stakeholders the strategy defines strategic goals (well-functioning and safe travel and transport chains, a smaller ecological footprint, technology and new practices have improved the efficiency of operations and made new services possible, etc.) and intermediate goals. Finally, the strategy is directly translated into asset specific objectives and targets (e.g. primary roads remain good), where requirements like safety, environment and availability are not so important in sparsely populated areas in Finland (e.g. congestion is a problem in one region only).

4.2.5.3 Monitoring and assessment

The different assets (pavement, bridges, tunnels etc.) are monitored or inspected in different intervals and to different extends based on national guidelines and standards. The assets are monitored periodically with high speed measurements on pavements (rutting, IRI) and in form of inspections (general inspection every 5 years and annual inspection) for the engineering structures.

The monitoring and assessment of other assets is in the responsibility of the regional offices.

4.2.5.4 Combination object level needs with the strategic targets and requirements

The Finnish Transport Agency carries out the combination of object level needs and strategic targets und the following framework:

- Strategic target is prepared at the central administration level to correspond with the target set by the ministry (service agreement)
- Strategic target and funding is then allocated to regions according to their assets, traffic and asset condition, where different regions might have different objectives
- Unified performance indicators are used at all levels and thus they are nationwide comparable (centralized database)
- Results are ensured through a holistic management by objectives (currently four year objectives with annual intermediate objectives)

4.2.5.5 Combination of needs of different assets (cross asset management)

The combination of maintenance needs of single assets is based on an assessment of each asset individually and brought together for funding and prioritization as follows:

- Long-term funding requirements to keep the status quo are first calculated for all types of assets (pavements, bridges, traffic management, gravel roads, road furniture, etc.)
- The asset specific needs will be summed up, where the total needs are usually higher than the available budget
- If funding is not adequate, the priority order is as follows
    - Routine maintenance of all roads
    - Traffic management
    - Ferry services
    - Pavement of important roads (trunk and main roads, other with AADT > 3'000 vehicles/day)
    - Road marking and important furniture
    - Critical engineering structures (bridges, tunnels)
    - Low volume roads get minimum funding

4.2.5.6 Categorization of cross asset management approach

The current approach of cross asset management procedures can be categorized as ***Top-Down solution*** with the following framework conditions:

- Strategy comes from the ministry in form of a service agreement
- Key performance indicators define the asset specific targets (maximum proportion of assets in backlog on all levels)
- The requirements and targets are directly introduced to all levels and define the maintenance activities
- Issues like environment and safety will be managed at the technical level

4.3 Analysis of Interviews

The following chapters present the results of the analysis of the responses of the interviewed road administrations. The comparison of the different aspects in the context of cross asset management, performance monitoring, asset management procedures, etc. is possible on a general level only but provides a good basis for the recommended solutions of PROCROSS. A detailed comparison of single definitions between the different road administrations is difficult because of different local requirements, input-data, standards, and preconditions.

4.3.1 Organisation and road network

The following Table 6 gives a first impression about the different road types, which fall under the responsibility of the interviewed road administrations. It can be seen, that most of the road networks can be described as the high level road network (federal trunk road network) with the exception of Finland, where beside the trunk roads also other roads including a large network of gravel roads will be managed by the Finnish Transport Agency.

Table 6: Road class overview

Road class	DE	NL	UK	FI
Motorways[1)]	●	●	●	●
Other primary roads[2)]	●	●	●	●
Other roads[3)]				●
Gravel roads (as part of the other roads)				●

1).....Roads with more than one lane in each direction, separated carriageways (mainly) and level free intersections.
2).....Arterial roads with one lane in each direction (mainly), no separated carriageways (mainly) and level or level free crossings.
3).....All other roads.

The lengths of the concerned road networks can be taken from the previous chapters. The smallest network is the London trunk road network with approx. 510 km in comparison to the road network of the Finish road administration with more than 78’000 km of different road types.

Beside the different road types also the organizational structure of the road administration with respect to asset management was considered during the interviews. The following Table 7 provides an overview and shows that the interviewed road administrations are offering a de-centralized organization, where the execution but also the management of maintenance activities will be carried out by the local branches.

Table 7: Organization of road administrations

Unit	DE	NL	UK (HA)	UK (TfL)	FI
Head (central) office	1	1	2	1	1
State departments / regional offices and other departments	16	18	9	33	9

4.3.2 Strategic targets and requirements

One of the decisive factors for cross asset management and finally for the definition of cross asset management optimization procedures are strategic targets and requirements. The interviews showed that in all road administrations strategic targets and requirements are defined either in form of strategic plans or service agreements (between the agency and the Ministry). An overview of the strategic requirements and targets and their use in the asset management processes can be taken from the following Table 8.

Table 8: Strategic requirements and targets

Definition of asset management strategies	DE	NL	UK	FI
Strategic requirements and targets defined	●	●	●	●
Strategic plans or service agreements in place	●	●	●	●
General description of requirements	●	●	●	●
KPIs with targets or thresholds	●	●		●
Transfer of strategic KPIs to object level	○	●	●[1]	●

●.....existing approach
○.....partially existing approach
●[1] .....TfL

Different strategic KPIs (with or without targets or thresholds) are the basis for the definition of the strategic requirements in the interviewed agencies. One exception was the HA as they do not (yet) transfer the technical performance indicators to a strategic level. In general, the condition related values are usually based on the technical assessment (monitoring, see chapter 4.3.3) and the estimated maintenance needs of the different assets, which will be brought together by using different procedures. The definition of the strategic requirements by using technical performance indicators enables transfer from the strategic level to the (local) object specific level of application.

4.3.3 Monitoring and assessment

Most of the road assets of the interviewed road administrations will be monitored at a high level. The output of the condition surveys and inspections are a high number of different indicators and parameters which will be used on the one hand for the planning of maintenance activities at an object level and on the other hand to define strategic targets and requirements (strategic KPIs).

The following Table 9 gives an overview of the monitoring and assessment procedures, which will be used in the asset management approach of the interviewed road agencies.

Table 9: Monitoring requirements and assessment of condition

Monitoring requirements	DE	NL	UK	FI
Monitoring and assessment of pavements (KPIs, thresholds)	●	●	●	●
Monitoring and assessment of engineering structures (KPIs, thresholds)	●	●	●	●
Monitoring and assessment of other assets (KPIs, thresholds)	○	●	○	○
Transfer of monitoring results into strategic targets and requirements	●	●	●[1]	●
Use of monitoring results for the planning of maintenance activities	●	●	●	●

● .....existing approach
○ .....partially existing approach or under development
●[1] .....TfL

4.3.4 Combination object level needs with the strategic targets and requirements

The procedures for the combination of the strategic requirements and tasks with the maintenance needs at an object level are strongly dependent on the organisational structure of the respective road administration and the general asset management approach (Top-down, Bottom-up, etc.).

In general, in those agencies, where only general requirements and targets exist, the object level maintenance needs mainly define and influence the maintenance programs. In those administrations, where clear pre-defined standards and thresholds must be fulfilled the object level maintenance needs have to be adapted according to these frameworks so that the maintenance program is a (optimized) combination of strategic and object level requirements.

The analysis of combination procedures between object level maintenance needs and strategic targets and requirements enables to define the type of approach (Top-down, Bottom-up, Top-down and Bottom-up). An overview of the transfer and combination levels can be taken from the following Table 10.

Table 10: Combination object level needs with the strategic targets and requirements

Level of transfer and combination	DE	NL	UK (TfL)	FI
General combination of strategic targets and requirements with object level maintenance needs	●	●	●	
Specific combination of strategic targets and requirements with object level maintenance needs (complex combination procedures)		●	●[1]	
Strategic requirements and targets transferred to object level only				●

●[1] .....TfL

4.3.5 Combination of needs of different assets (cross asset management)

Beside the combination of strategic and object level the coordination of maintenance measures is another decisive factor in the asset management processes. At the moment most of the European countries combine the needs of the single assets (pavement, bridges,

tunnels, etc.) by using engineering judgment taking into account strategic requirements (e.g. availability) to varying extents. In some countries a more sophisticated optimization approach (e.g. analysis of cross asset treatment strategies) is under development, which enables on the one hand a better and more objective assessment of possible solutions and on the other hand an integration into existing processes and procedures.

The following Table 11 shows the level of application of procedures for the combination of maintenance needs of different assets.

Table 11: Combination of needs of different assets (cross asset management)

Level of transfer and combination	DE	NL	UK	FI
Combination based on engineering judgment	●	●	●	●
Combination procedures based on analysis		●	●[1]	
Decision support tools for combination procedures	o	●	●[1]	

●.....existing approach
o.....partially existing approach or under development
●[1] .....TfL

Within Table 11 it can be seen, that only Rijkswaterstaat (The Netherlands) and Transport for London (UK) has a procedure and a system in place, which enables to assess and finally prioritize combined object classes.

4.3.6 Categorization of cross asset management approach

With regard to the detailed information about the asset management procedures of the interviewed road administration it is possible to categorize the cross asset management approaches according to the Direction of Decision into the following 3 classes. These 3 classes were derived from the gathered information (see chapter 3 and 4) and the have to be understood as a general categorization. In some cases the approaches show a certain overlap or are a combination, where on part is mainly used.

- Top-down approach: the strategic targets and requirements define the maintenance measure at an object level to a wide extent; the maintenance needs of the single assets have to be subordinated to the strategic targets and requirements
- Bottom-up approach: the maintenance needs of the single assets are the decisive factor in the decision process; the strategic targets and requirements derive directly from the object level
- Top-down and Bottom-up approach: strategic targets and requirements meet the maintenance needs of the single assets in the middle of the decision process; the decision process is a closed loop of Bottom-up and Top-down.

As already mentioned the following classification in Table 12 is a general estimation, which can be in detail more complex and pass in other ranges.

Table 12: Classification of cross asset management procedures

Class	DE	NL	UK	FI
Top-down				●
Bottom-up				
Top-down and Bottom-up	●	●	●	

As shown in Table 12 the majority of the interviewed road agencies could be classified to the “Top-down and Bottom-up” approach. As already mentioned, the approach is strongly dependent on different influencing factors and their different importance. As an output of the investigations the following main factors can be listed according to their importance for cross asset management:

- Organisation of road agency (central, de-central, number of staff, etc.)
- Field of responsibility of road agency (number of assets, type of assets, etc.)
- Availability of strategic targets and requirements (SLA, strategic plan, etc.) and definition of KPIs
- Method of budget allocation
- Contracting
- Data availability, monitoring and methods of object level analysis

4.4 Conclusions

Within Deliverable 2 “Effective monitoring of road infrastructure assets” the governing factors for cross asset management were collected and assessed in close cooperation with European road administrations. The respective workshop and especially the expert interviews carried out with Germany, The Netherlands, United Kingdoms and Finland were resourceful to answer the questions. The summary provided shall serve as a guide for future development within PROCROSS and builds the frame for the following tasks (i.e. WG3: Development of cross asset management optimisation procedures).

According to the interviews we conclude that the governing factors in cross asset management are:

- *Understanding the different cross asset management approaches (i.e. top-down, bottom-up).*
- *Defining the strategy (e.g. SLA, ministry contracts with NRA)*
- *Definition of performance indicators on a technical and strategic level.*
- *Common and mutual understanding of the defined performance indicators on a technical and strategic level.*
- *Understanding the needs and requirements per asset.*
- *Organisational structures (centralized vs. decentralized).*
- *Common basis (i.e. data, standards, guidelines) and understanding of decision making per asset.*
- *Consideration of lifecycle performance.*

Outlook

Due to the results so far the following tasks are suggested for further work within PROCROSS:

- *To propose a combined framework for existing managements systems (BMS, PMS, etc.) within a cross asset management meeting strategic objectives (bottom-up meets top-down)*
- *To develop and adapt an optimization procedure identifying and suggesting a cross-asset maintenance programme based on the needs and requirements of each asset in order to meet the strategic targets.*
- *To develop an adaptation strategy and guideline supporting road administrations in implementation of cross asset management procedures*

The following research topics remain for current or future research projects and are not dealt within PROCROSS:

- *Development of a full risk-based approach for decision making in cross asset management.*
- *Common understanding for a widespread set of relations between strategic and technical performance indicators (e.g. accident risk model based on road*

infrastructure data).

- *Large-scale dissemination of knowledge (i.e. handbook or guideline).*
- *Harmonization of building information management*
- *Emphasize training of professionals (young academics tracks, etc.).*

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ANNEXES

A: Interview Guide

B: TAB Workshop Questionnaire

ANNEX A: Interview Guide

Name		**Country**	
Organisation		**Date**	
Road Network			
Regional Departements			

What strategic targets and requirements are used in the asset management process?

Strategic targets and requirements	**Key performance indicator**

How do you monitor and assess the different assets on object (technical) level?

Asset	Monitor and assessment	Key performance indicator
Pavement		
Engineering structures		
Others		

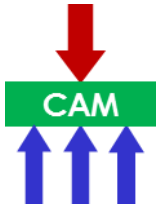
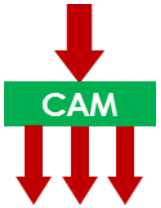
How do you combine the needs on object level with the strategic targets and requirements?

Asset	Method / approach
All	

How do you combine the needs of the different assets?

Method / approach

Which approach does fit mainly to your asset management processes?

ANNEX B: TAB Workshop Questionnaire

PAVEMENTS

road ERA net Vienna 2011

Name		Country	
Organisation			

How do you assess the different Performance Indicators for Road Pavements?

Network	Performance Indicator	How do you assess the value of the indicator (technical parameter)?		
Motorways	❒ Skid resistance / Texture	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Longitudinal evenness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Transverse evenness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Structural condition (cracking, bearing capacity, etc.)	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others (raveling, bleeding, etc.) _____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
Other primary roads	❒ Skid resistance / Texture	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Longitudinal evenness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Transverse evenness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Structural condition (cracking, bearing capacity, etc.)	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others (raveling, bleeding, etc.) _____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
Secondary roads	❒ Skid resistance / Texture	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Longitudinal evenness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Transverse evenness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Structural condition (cracking, bearing capacity, etc.)	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others (raveling, bleeding, etc.) _____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
Other roads	❒ Skid resistance / Texture	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Longitudinal evenness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Transverse evenness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Structural condition (cracking, bearing capacity, etc.)	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others (raveling, bleeding, etc.) _____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure

ENGINEERING STRUCTURES

road ERA net Vienna 2011

Name		Country	
Organisation			

How do you assess the different Performance Indicators for Engineering Structures?

Network	Performance Indicator	How do you assess the value of the indicator (technical parameter TP / Index)?		
Motorways	❒ Corrosion	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Cracks	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Deformation / stiffness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Structural safety index β	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others _____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
Other primary roads	❒ Corrosion	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Cracks	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Deformation / stiffness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Structural safety index β	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others _____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
Secondary roads	❒ Corrosion	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Cracks	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Deformation / stiffness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Structural safety index β	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others _____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
Other roads	❒ Corrosion	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Cracks	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Deformation / stiffness	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Structural safety index β	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others _____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure

ROAD FURNITURE

road ERA net Vienna 2011

Name		Country	
Organisation			

How do you assess the different Performance Indicators for Road Furniture?

Network	Performance Indicator	How do you assess the value of the indicator (technical parameter TP / Index)?		
Motorways	❒ Serviceability	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Stability	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Reflectivity	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others			
	_____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	_____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
Other primary roads	❒ Serviceability	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Stability	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Reflectivity	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others			
	_____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	_____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
Secondary roads	❒ Serviceability	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Stability	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Reflectivity	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others			
	_____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	_____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
Other roads	❒ Serviceability	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Stability	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Reflectivity	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	❒ Others			
	_____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure
	_____	❒ TP directly used	❒ Index (normalization)	❒ Calculation procedure