ASSESSMENT OF BUDGETARY NEEDS AND OPTIMISATION OF MAINTENANCE STRATEGIES FOR MULTIPLE ASSETS OF ROAD NETWORK

Technical Committee C.4.1 Management of Roads Assets of World Road Association
The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

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Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organisations or agencies.

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Good road infrastructure is a fundamental basis on which to build a strong economy and society. It is a substantial factor that significantly affects the rate of economic growth. Proper maintenance planning and execution is therefore very important. As the ability to conduct proper maintenance is largely influenced by the available budget, budget definition is an important starting point in realising the overall goal.

Based on a comprehensive investigation in the form of interviews with public road administrations and private sector concessionaires, a large quantity of information on good practice in budgetary assessment and optimisation of maintenance strategies, as part of the overall management of road assets were collected during the last 4 years from around the globe. The results of these interviews were analysed and discussed. As an output of these activities, recommendations have been given for an improved, or better asset management of actual or planned road infrastructure assets. This has been summarised as follows:

- many road authorities have some sort of long term strategic plan that relates to many performance indicators. This long term strategic plan is relevant to the prioritisation in budgetary allocation;
- from the interviews it was observed that all road authorities face constraints in definition of the budgets. Constraints are either related to budget or qualities to be delivered or both. Also the extension of road network and/or changes in assets within the network results in a constraint on the budget. A way of coping with the budgetary constraints is to present choices related to the strategic plan. One of the approaches, is by using business cases presenting both, the ideal situation as well as alternative strategies in showing the expected results and consequences. Consequences to be shown with respect to spending, resulting qualities and/or risks;
- strategic targets and requirements are important for a repeatable and objective asset management process. In particular, the comparison of the actual situation with these targets has an essential impact on any decisions in the maintenance process. Nevertheless, strategic targets and requirements are set to a level, which could be achieved under the given constraints, coming from the financial, the organisational and other (external) preconditions and situations. Strategic targets and requirements should be defined, as a minimum for safety, comfort and structural issues. A straight forward and reproducible process for monitoring and assessment against those targets should be implemented;
- the combination of maintenance needs of different road infrastructure assets set into a harmonized maintenance or construction program, enables a significant reduction in the negative effects on the users, the neighbours, the environment and other stakeholders. Thus, it is important to provide and assess the asset specific data (inventory, condition, etc.) and maintenance needs in a cross asset specific form, where engineering judgement and assessment is possible and the strategic targets and requirements can be included. A combination of a bottom-up and top-down approach is the recommended procedure. Most countries currently use cross asset management for coordination and prioritisation. Most road administrations and concessionaires are using engineering judgement while developing an optimisation process. The main difficulty they are facing is the complexity of the task to build a universal ranking scale for all assets allowing for a holistic process;
• there is a tendency within the road authorities to move from the technical asset management plan to a more detailed argumentative version that relates to strategic targets and public interests. Some road authorities already use an explicit business case in support of budget allocation and the results derived are related to the strategies in place. Also the use of external auditing when reporting on the results obtained, is starting to become more common. The technical committee envisages a detailed business case approach as the way forward in relating the performance of the asset management organisation in meeting those public interests and therefore, also those politicians making the final decisions in allocating budgets. For private concessionaires such a business case approach is more common due to the nature of these organisations;

• risk management should be an integral part of asset management business cases. The assessment of risk, based on the probability and consequence of failures, enables a better understanding of the decisions and their effects in asset management. Risk management should be included at an object (project) level as well as on network level, where the effects of maintenance activities on the whole network (e.g. closure of an important network link) has to be considered;

• many road authorities have an interest in knowing where they stand in performance relative to other authorities. In general, benchmarking is seen as the technique to be used. But from the interviews no useful data was found on the techniques to do a simple benchmarking study. Many aspects influence the results and they should be accounted for when delivering the results of a benchmark. Within Europe an extensive benchmarking study was established through “BEXPRAC”. Although some conclusions could be drawn on the efficiency of the organisations, it was also shown that many uncertainties were related to the results. Differences in the asset base, but also the way costs are accounted for within organisations are relevant when dealing with benchmarking results.
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1. INTRODUCTION

1.1. BRIEF BACKGROUND

This report is based on literature review, interviews (based on a questionnaire), a seminar held in Mexico, technical meetings and expertise of the Technical Committee.

During the cycle of the Technical Committee, a Latin American Working Group was instituted. By means of the members in the Technical Committee from Chile and Mexico, the regional workgroup contributed to the work of the workgroups and therefore the contents of this report. On the specific Latin American input, the Latin American Working Group prepared a separate report [1].

Road infrastructure is one of the fundamental bases on which to build a strong economy and society. It is a substantial factor that significantly affects the rate of economic growth. Road Authorities all around the world have recognized the importance of proper maintenance and maintenance planning in order to encourage sustainable society development.

Sustainable society development is something that does not happen overnight. Each action – whether it is road maintenance or legislation – has its own positive or negative effect that can be experienced differently by the stakeholders. Stakeholders can be internal (road management authority and government) or external (e.g. general public, private sector). Therefore, the results of these actions have to be continuously monitored and reported upon. Road maintenance and its programming are subject to this cycle of planning, executing and monitoring. The road maintenance program, the associated budgets and the optimisation processes in selecting feasible road maintenance strategies within the plan should reflect this.

Current budgetary needs, maintenance strategies and optimisations leading to works programmes are the result of long term (strategic) planning and historic construction and maintenance works on the road network. The long term strategic plan provides the road authority with a means that can be used as a guide in defining current and future budget needs and where to put energy or focus. Historic construction, use and maintenance works lay the foundation from which the current budget needs arise. Historic data can also provide information which can be useful when prioritising within the available budget.

A full understanding of the preparation of road infrastructure portfolios that support the long term strategic plan (from local to regional, national and international level) is necessary to enable the optimisation process. It takes its starting point from the established transport policy for the selection of suitable strategies. These strategies are incorporated in business cases to be realised in both the short and long term. Business cases are based on the current condition of assets and regular maintenance treatments. Irrespective of the time horizon, the strategic plan needs to:

• provide a clear understanding of the expected achievements, as consequence of the proposed budget for road network development;
• be transparent in order to facilitate communications between different stakeholders;
• be a basis on which cross-asset optimisation and risk optimisation become viable as a means to select the most optimal maintenance strategy – given a certain budget.
The business case is then presented to politicians and/or commercial parties to enable budgets to be released to execute the plans. Any business case should be monitored and reported upon.

1.2. PURPOSE AND OBJECTIVES OF THE DOCUMENT

The purpose of this report is to provide users with information on good practice in budgetary assessment and optimisation of maintenance strategies as part of the overall management of road assets. Although most of the contents are based on current practice in Europe, North America and Australia, these practices can also be put to use in developing countries and countries in transition. To help with the implementation of good practice, special emphasis is given on the application of the findings to countries with less available data and less sophisticated data analysis systems.

The objectives of this document are:

• to provide useful information on good practice for budget assessment
• to provide useful information on good practice for cross-asset optimisation of maintenance strategies;
• to highlight the importance of detailed accounting on budget application and its effects on current road and asset condition;
• to highlight the application of risk assessment as a means to allocate budgets to locations and asset types;
• to highlight the complications and challenges met by road authorities when benchmarking performance and costs.

1.3. SCOPE OF THE DOCUMENT

The report covers a wide range of issues, including:

• strategic targets and requirements as part of the road maintenance business case;
• relevance of targets and requirements to budget definition and presentation;
• the use of different planning horizons and their implications on the road maintenance business case;
• expenditure and funding categories as part of detailing budget allocation and benchmarking;
• asset monitoring and assessment to define effects of road maintenance in relation to the long term strategic plan;
• budget calculation and financial forecasting;
• cross asset optimisation of the maintenance program and the use of risk management techniques;
• defining and submitting maintenance business cases;
• benchmarking and comparison of budget needs.

The goal of the report is to present good practice in budget calculation and optimisation of maintenance strategies. The report does not contain detailed technical information on the actual practice itself or supporting systems.
1.4. METHODOLOGY

The Technical Committee followed this approach in respect of the set task:

- definition of the work program related to the strategic tasks set by the Council of the World Road Association in the strategic plan 2012-2015 with special emphasis on:
  - definition of assets to be included in the study;
  - definition of term “maintenance” covering the tasks as part of the maintenance business case;
  - definition of terminology;
- literature research;
- conducting interviews with experts within the PIARC member countries (The interviews were conducted on basis of a pre-set questionnaire);
- categorisation and analysis of the results of the interviews;
- definition of “good practice” in budget definition and allocation including cross asset optimisation.

1.5. STRUCTURE OF THE REPORT

Based on the information collected during the interviews, the analysis of the results and the discussions carried out within the Working Groups, the report is structured so that the findings are provided at the beginning followed by more detailed information on the interviews and analysis of the interviews. The report is, therefore, structured as follows:

- **PART A**: Findings from the work of the Technical Committee
  The findings from the interviews with public road administrations and private concessionaires are described in this part. Each main chapter gives an introduction, followed by information about good practices and concludes with findings and specific recommendations. Results from public sector and private sector are discussed separately.

- **PART B**: Results from the interviews
  The results of the interviews were analysed and summarised in tables, which enable a direct comparison of the different interviewed authorities. The tables are listed in this part of the report and have a direct link to the questions asked during the interviews.
PART A: FINDINGS FROM THE WORK OF THE TECHNICAL COMMITTEE

2. APPROACH TO DEFINE FUNDING NEEDS

2.1. Introduction

Good road infrastructure is a fundamental basis on which to build a strong economy and society. It is a substantial factor that significantly affects the rate of economic growth. Proper maintenance planning and execution is therefore very important. As the ability to conduct proper maintenance is largely influenced by the available budget, budget definition is an important starting point in realising the overall goal.

Development of infrastructure networks takes time. Due to this time aspect, a network will consist of assets of many different age-classes, related conditions and associated risks. Having a consistent long term plan helps in making the right decisions when defining and prioritising the maintenance business case. The long term plan should encompass goals, tactics and indicators that illustrate whether the goals are met (dashboard). It should focus not only on maintenance but also on the relationship between infrastructure development and changes and innovations in society (e.g. electrical cars, automotive vehicles, shifts in modal split). Involvement of wider industry is important to be able to identify such changes.

Illustration 1 shows a concept for planning, from a strategic level down to implementation of planned activities. The concept is taken from Swedish input during the interviews and can be found (in adjusted forms) in many road authorities.

![Illustration 1 - Concept for planning from strategic level to implementation of activities](image)

The strategic level of planning is the fundamental basis for the preparation of future road (investment) infrastructure portfolios. The essence of long term planning is to set up suitable tactics for effective achievement of predefined goals and objectives in the established strategy. Conditions, measures and effects all contribute to define the shortcomings, evaluate possible solutions, develop works programs and detail the effects on the intended development. The level
of detail in reporting conditions, measures and effects changes over the planning horizon. Long term planning is mostly abstract, whereas short term maintenance work programmes are detailed.

A budget will always be made available each year. Whether the budget completely meets the needs will always be arguable. Given a certain budget the best approach for the authority will be to allocate it to the activities that have most effect on the set strategic targets, and detail and communicate the risks elsewhere when a budget shortfall is observed.

2.2. Good practice from public sector

As already described in the introduction, consideration of a wide variety of strategic targets other than just maintenance, forming part of the definition of budget needs seems to be the way forward. From the interviews, it was shown that some countries are now trying to achieve this goal. Aspects considered include:

- environmental targets as part of the budget definition process;
- dissolving the budgetary boundaries between investments, improvements and maintenance;
- risk management as part of the evaluation process, therefore forcing the introduction of the concept of uncertainty in the budget definition;
- continuous monitoring during the year instead of intervals between inspections to facilitate programme adjustments to meet the needs and required achievements.

In general it can be observed from the interviews that all authorities follow some sort of structured approach in the budget definition process. Every 1 to 4 years the defined budget is reviewed. All budgets have some relationship with the asset collection managed, therefore showing the need for an accurate asset dataset (amount, type and condition).

Whether the budget definition process involves performance indicators and risk indicators seem to depend on the maturity of the asset management organisation. Almost all organisations are believed to use them one way or another, but the question is whether it is explicit or not.

2.3. Good practice in private sector

The private sector seems to follow, in general, similar processes to those in the public sector. It can be observed though – mostly due to their focus on the return on investment and also their contractual obligations – that the private sector seems to be more focused on the risks associated with managing their assets and also delivery of the program in respect to the requested performance. Regular budget updates and rolling forecasts can be found.

2.4. Fundamentals to be applied when considering budget definition

2.4.1. Asset collection

The necessary budget is largely dependent on the composition and condition of the asset collection and its use. Therefore, a good dataset is vital to the budget definition. The dataset should at least give information on:
• quantity of assets (e.g. number, surface area)
• asset type (e.g. roads, structure, road side furniture);
• asset composition data (e.g. type of material, structural strength);
• location of asset in road network (function, criticality in network resiliency);
• condition data (e.g. age, damage/distress, historic maintenance/rehabilitation),
• use data (e.g. traffic volume, traffic constitution);
• cost data (e.g. costs of specific maintenance treatments, maintenance cycles).

With a comprehensive and reliable dataset it is possible to perform analyses on the use and degradation of the assets and the need for maintenance including its cost. Furthermore, with such a dataset it is possible to relate the current asset collection to network performance and risks. This provides options for network performance and risk analysis providing the necessary information to relate strategic planning to the current need for maintenance on specific assets.

Advice to authorities with less available resources
Maintaining a good dataset is vital for managing assets. If a dataset is not maintained properly, all data within the dataset will soon become obsolete and questionable. Therefore, it is advisable to limit the dataset to what can reasonably be maintained. The minimum dataset required is asset type, locations, quantity and condition data.

2.4.2. Strategic targets and requirements

To a certain extent, the necessary budget is related to demanded performance and acceptable risk levels for the road authority. Performance and accepted risks are normally translated into targets and requirements to which the current asset state can be compared. Differences between targeted and delivered performance prompt a need for maintenance or enhancement of the asset.

In this report targets or objectives have been broadly divided into six categories, namely:

• Physical condition targets – these relate to the physical condition of roads and bridges and other assets and are the most common types of parameters applied that directly relate to maintenance actions and maintenance costs. Examples of these are roughness or comfort parameters, rutting parameters, visual inspections of pavements, bridges and roadside furniture and indices derived for measures of physical condition.
• Safety related targets - these are either stated at a broad level in terms of road safety targets (outcome), for example level of fatalities or in terms of skid resistance parameters that have a more direct impact on determining works programmes.
• Asset sustainability parameters – these can relate to simple targets for replacement of assets, resurfacing programs based on age profiles or “backlog” targets. At a more sophisticated level parameters can relate to financial parameters describing the sustainability of the assets from a financial valuation perspective.
• Network operational targets – these generally relate to the efficiency of the operation of the road network, in particular congestion, travel times, capacity, journey reliability, etc. While these are very valid agency targets, these types of targets or outcomes can have influence on maintenance programs (preventative versus curative measures) or the justification of maintenance funding.
• **Budget execution** – targets related to performance of the maintenance programme against the approved budget, these can include accuracy and timeliness of budget spend, achievement of efficiency targets etc.

• **Environmental Considerations** – targets relating to application of environmental standards, use of recycled materials or innovative materials

• **Stakeholders** – Targets relating to stakeholder interests either internal (the road authorities organisation) or external (e.g. public).

### Advice to authorities with less available resources

Any target defined has to be monitored. Therefore, limiting the amount of strategic targets that are part of the budgeting process is a reasonable approach to manage available funding. It is advisable to define targets at least on physical condition, safety and budget execution.

### Physical Condition Parameters

**Road pavements**

Targets related to physical condition are by far the most common type of target for road pavements. Justification of these targets from safety or economics is less apparent. Practice seems to be the dominant factor in definition of the targets. This practice is either based on engineering consent or panel ratings with road users.

Road roughness (IRI) is the most common measure reported and is applied in a number of ways:

- by setting IRI targets for different classes of roads;
- by setting a general overall roughness target;
- as an input into a ride quality index;
- as input into a broader pavement condition index.

Correlation between road roughness and vehicle operating costs is widely reported. It could be questioned though whether there exists a certain threshold from which increasing ride quality does not reduce vehicle operating costs. As developed countries tend to target high ride quality, the immediate economic justification of roughness targets for these countries is less apparent. For countries in transition and development road roughness is very important in selecting the most viable investment and repair schemes.

Use of structural measures or a structural index is less frequently reported. The structural dimension of pavements appears to be less well applied at a network level or as a strategic target. Some authorities apply rebuilding targets (discussed below under the sustainability targets).

Use of visual condition surveys is also common, often as an input to a pavement condition index. For visual condition surveys, cracking, rutting, raveling and evenness appear to be the most common indicators. These are relevant across to safety (rutting, evenness), economic (evenness) and structural condition (cracking, raveling). Inspection regimes vary from annual surveys to detailed inspections every 3 years.
Bridges and Structures
Targets for bridges and other structures tend to be set in terms of % of structures in levels of condition or in terms of a quality index target for structures or elements in structures. Here too, practice appears to be the dominant factor in definition of the targets. This practice is predominantly engineering judgment.

Monitoring / inspection of bridge structures is the most common approach in defining condition. Visible defects tend to define maintenance programmes although risk based approaches are also used. In the risk based approach visible defects and other deficiencies are analyzed and weighted. Condition data along with risk data is input to Bridge Management Systems. Inspection regimes vary from annual surveys to detailed programmed inspections every 6 years.

Roadside Furniture
The setting of condition targets for road infrastructure other than road pavements and bridges tend to be less well developed worldwide. It can be observed that some countries focus on specific types of assets to be included in the analysis of asset performance. The focus tends to be related to past experience, i.e. problems / accidents that caused a lot of public attention.

The assessment and maintenance of systems associated with electronic assets and tunnels is scarcely reported. It would appear to be an area of increased need for attention given the increasing quantity and shorter life of these assets in modern road systems.

Safety Parameters
Safety targets tend to be applied at an agency level and are impacted by a range of interventions including new infrastructure, safety projects, maintenance activities, non-build interventions as well as safety campaigns. They are mostly defined in fatality numbers, both, road users and road workforce. There is no evidence that high level safety targets have a dramatic impact on maintenance budget bids.

For “safety measurements” of the asset, the use of friction measurement to assess pavement skid resistance is commonly reported. It is used primarily as an input at programme development level. There was no mention of a specifically funded road surface skid reduction program amongst interview responses.

Asset sustainability
The ability to sustain the level of service provided by existing road assets remains a key concern of road authorities, particularly as many road pavements and bridges in developed countries are reaching or have reached the end of their service lives. A number of road authorities include the reconstruction of assets at the end of their service life as an integral component of the Maintenance programme and the Maintenance budget.

Targets relating to sustaining assets are normally one of the following:

• simple output targets around % of network to be treated. This can apply to amount of road resurfacing works, amount of pavement rebuilding works, bridge replacement targets, culverts replaced, etc.;
• targets relating to a maintenance backlog;
• targets relating to the age of pavements or road surfacings;
• financial targets relating to the relative financial value of assets (or loss of value);
• targets relating to residual life of pavements.

Interview responses indicated that the use of financial indicators relating to the written down value of assets is gaining increased credibility and traction with government funders who often approach budgets from an economic perspective. Discussing asset replacement needs in terms of written down value and changes in written down value also provides a mechanism and language that can be used in common across government infrastructure.

**Budget Execution**

All road agencies generally closely monitor budgets as a normal part of doing business. Indicators used are:

• % of work progress against targets;
• deviation from original budget;
• monitor and benchmark costs;
• close monitoring and reporting against recurrent budget efficiency targets.

**Environmental consideration**

Road agencies are generally paying increased attention to the impacts on the environment when carrying out road construction and road maintenance works. Use of recycled materials, sustainable materials and limiting CO2 are all part of production process and are parameters that can be used. It should be noted, however, the experience with such indicators is limited.

**Stakeholders**

Most authorities include a wide range of stakeholders in the maintenance strategy. Most common are users, owners and operators. Others include neighbours, financing bodies and society as a total group.

**2.4.3. Planning horizon and options**

When budgeting, one has to take into account the fact that future income and expenditures are less certain than the current. The reason is that many aspects can change over time, e.g. the maintenance programme has to be prepared during which both technical as well as stakeholder wishes have to be implemented.

Most agencies use at least two planning periods (short term and mid/long term). Some make a difference between mid and long term budget plans.

**Short term**

The short term plan consists mainly of a detailed works or construction programme in which projects are named including budgets. The program is normally defined annually and is fed by the mid-term plan. The short term plan can in most cases be envisaged as an operational plan. A few authorities do not produce a short term plan as a specific document. It is believed that
these authorities still have a list of priorities that can be seen as such a plan. Another option is that these authorities contract all maintenance works during a certain period (e.g. 1 to 3 years) to a contractor where the contractor is responsible to define the short term works programme and deliver specified performance from the network and individual sections in the network.

**Mid-term plan**

The mid-term plan is also called the tactical plan. It consists mostly of reconstruction, rehabilitation and large repair works and a general budget for (smaller) maintenance works. It is defined on the basis of condition assessments and other input (e.g. from stakeholders). Financial parameters are taken from past projects. Estimates of the project prices are made on an abstract level not detailing all specifics. The focus is on deriving a budget in which the final project can be executed.

The planning horizon can be up to 15 years, although most authorities appear to limit the period to 5-7 years. Depending on the planning horizon, the contents of the plan will be more focused on rehabilitation and reconstruction or repair works.

The plan is used for budgeting but also for communication with stakeholders. Furthermore, given a specific midterm plan, options can be incorporated in the plan to deliver the strategic targets set by the long term plan.

**Long term plan**

The long term plan has a strategic objective. The planning horizon is generally between 10–30 years and in some cases up to 50 years. It is based on condition and traffic predictions and development scenarios. In some cases, the asset value is also part of the plan. The main reason to produce the strategic plan is for long term budget evaluation and master planning in relation to the development of the infrastructure network.

**Advice to authorities with less available resources**

There is no real advantage to be derived from limiting the planning horizon. It could be argued that, especially in case of budget downfalls, having a long term vision becomes even more important.

2.4.4. Expenditure and funding categories

Many road authorities separate Capital Expenditures (CAPEX) and Operational Expenditures (OPEX). Together, they deliver the complete infrastructure works programme to meet set targets. CAPEX and OPEX are often from different funding sources that are accounted separately. What is attributed to CAPEX and OPEX can differ between different authorities. Within a single agency this is not an issue, but when comparing costs and performance of different agencies (benchmarking) it becomes an issue. Costs that are attributed to OPEX in some cases are accounted as CAPEX on others and vice versa.

Another aspect to take into consideration is that authorities can differ in the way they estimate costs and attribute costs to budgets. Common elements in the structure of estimates are:
• finance / capital costs;
• depreciation of the asset;
• operations;
• maintenance;
• administration;
• profit (some cases).

Whether these are all included in the maintenance budgets is always the question. For example, in some road authorities, administration can be labelled as organisational costs that are part of another budget within the authority. Here too, within a single agency this is not an issue, but when comparing costs and performance of different agencies (benchmarking) it becomes an issue.

Advice to authorities with less available resources
There is no real advantage to be derived by not labelling expenditures. It could be argued that, especially in case of budget downfalls, having an expenditure structure becomes even more important in accounting for how the available budget was spent. It also helps in demonstrating cost efficiency.

2.4.5. Organisational ability to deliver the maintenance programme

The road authority never delivers the maintenance programme completely on its own. All kinds of stakeholders are normally involved. When developing the work program from the current conditions / needs and strategic plan, the asset manager should take this into account.

As much work is contracted to external companies, the way industry develops and changes (to become more efficient) is an important factor in achieving set goals. Only when industry is involved will the authority get early information on the way the infrastructure system will develop, opening the ability to decide what current actions will contribute to the future development. Furthermore, to get “value for money” industry has also to be challenged to develop, to become more competitive and cost effective and introducing new concepts and innovations in delivering their products. Only then will efficiency help the authority in making it possible to maintain the ever increasing amount and complexity of the network without the need to continuously increase maintenance budgets.

Also within the organisation of the authority itself, there should be an ongoing drive for ever increasing efficiency. Quality management and organisational development programs should, therefore, be part of the overall strategic plan of the organisation.

Advisory to authorities with less available resources
It is very important to become as cost efficient as possible, especially in case of budget downfalls. Getting stakeholders and industry involved in the budgetary problems is very important in identifying options for increasing efficiency.
3. USE OF ASSET PERFORMANCE MONITORING AND ASSESSMENT

3.1. Introduction

Holistic asset management and asset management processes have to be based on information describing the performance of road infrastructure assets. Only a comprehensive knowledge of asset performance leads to an objective assessment and finally to a good asset management strategy. Data, describing asset performance, can be powerful from a number of points of view. Road authorities are able to find optimum technical decisions for maintenance treatment strategies subject to the given requirements and preconditions (maintenance budgets, standards and guidelines, etc.). They are also able to mediate with and between the different stakeholders, including those who are providing the needed money (financial body), those who are affected by maintenance treatments (users and neighbours) and those who are sensitive to impacts on the environment.

The basis for and origin of most asset data is performance and condition monitoring. Monitoring can be carried in different ways subject to the asset type (pavement, bridge, roadside furniture, etc.), the density of data to be needed, the techniques to be applied (measurement, visual inspection, etc.) and the follow up assessment procedures, which are usually based on standards and guidelines. Most of the monitoring techniques are technically driven, where the outputs are performance indicators in the form of technical parameters (damage, extent and severity) and/or dimensionless values (indices, condition classes, etc.). Inventory data (road geometry, construction type, material, etc.) are also essential in the asset management process and need to be collected also.

The following chapters give an overview of asset performance monitoring and assessment procedures for the public and the private sectors.

3.2. Good practice from public sector

The following information was extracted from the public sector interviews for the different asset types making up the road infrastructure assets:

- Monitoring of pavements is conducted in all cases by measurement and is sometimes supplemented by visual inspection. The monitoring intervals range from 1 to 7 years in developed countries and 1 to 3 years in countries with developing economies. High speed measuring devices are used in all countries and visual inspections, video imagery, or other digital media are used to get a detailed view of the road surface. Many public road authorities (especially in developed countries) reduce monitoring intervals to obtain higher data density.
- Monitoring of engineering structures (bridges, retaining walls, tunnels, etc.) is by visual inspection in all cases at interval of 1 to 6 years in developed countries. A lack of data collection and monitoring could be seen in countries with developing economies.
- For roadside furniture and other components (electrical equipment, culverts, and geotechnical assets) only visual inspection is used, often in combination with routine inspection by the service provider. In countries with developing economies, roadside furniture is monitored by visual inspection, in some cases (traffic signs) measurements are made.

The periodical collection of data in form of measurements and visual inspections on pavements and bridges is now “state of the art” in developed countries as well as in many countries with...
developing economies. The actual monitoring methods and procedures provide the basis for extension into other assets.

Good practice from the public sector is driven by the need to conduct asset monitoring by using high speed measurement devices for a maximum reduction of road user disturbance and to get a comprehensive overview of asset performance on the whole network. All road authorities recognised that objective data leads to objective results within the asset management process.

3.3. Good practice in private sector

The output of information analysis subject to the different asset types and categories, is as follows:

- Monitoring for pavements in all cases takes place by measurement and visual inspection at intervals from 1 to 5 years.
- For engineering structures monitoring is by visual inspection at intervals from 1 to 6 years.
- For roadside furniture monitoring is by visual inspection is conducted in all cases and carried out partly in conjunction with other routine inspections.

In comparison to public road administrations and authorities private road operators have to fulfill asset performance monitoring processes based on pre-defined contracts and specifications. Thus, the selection of technical parameters and indicators as well as the intervals and type of monitoring is limited by those contracts.

Most of the monitoring procedures in the private sector are comparable to the public area because the methods, devices and standards are similar. An intensive monitoring of all assets is also the basis for any following up asset management activity. Data from asset monitoring will be used for the evaluation and the assessment of given targets as a part of the performance contracts and to a wide extent for internal decision processes.

3.4. Asset performance monitoring as a basis for asset management

The periodical collection of data in the form of measurements and visual inspections on pavements and bridges is “state of the art” in developed countries as well as in countries with developing economics and is the basis for extensions into other assets. On concessions in particular, the extent of data collection and monitoring covers most of the assets to be taken into account within asset management (depending on the definition and the type of the contract). There are no large differences between asset management organisations observed. In particular, the selection of adequate performance indicators for the description of asset performance is standardised in many organisations based on guidelines and regulations.

Almost every road administration (public and private) stores collected information in databases. Furthermore, many road administrations are using (sophisticated) asset management tools (Pavement Management Systems, Bridge Management Systems, etc.) to support the decision making processes in finding the best maintenance treatment strategies for a specific asset.
### Advice to authorities with less available resources

The monitoring of assets and sub-assets should be limited to the actual needs, which are based on the actual or planned asset management processes. The intervals of measurements (pavement) and inspections (engineering structures) should not exceed more than 6 years. Collected data and information should be stored in commercial databases or asset management tools, which offer a high level of flexibility in adjustment and support the decision making processes.

### 3.5. Strategic targets and requirements

Knowledge of the asset performance allows an assessment of the actual situation in terms of fulfilling the given strategic targets and requirements. Most of these targets and requirements can be linked to different stakeholders’ expectations. The principal stakeholders covered within the strategy are the users (including society), owners and operators, financing bodies and neighbours. The interview analysis provided the following conclusions:

- The main strategic targets which are mentioned by almost all road administration (public and private) are safety, comfort, structural condition, environment but also to a lesser extent customer (user) satisfaction, availability and the given budgetary situation. Also, in countries with developing economies, in particular, environmental aspects and sustainability show a high significance.
- The integration of the strategic targets into the specific asset maintenance process together with decision support tools is completely fulfilled for pavements and engineering structures. For roadside furniture this integration takes place to a lesser extent, and mainly without specific decision support tools.
- The translation of such strategic targets and requirements into technically driven indicators is a problematic field but is the basis for clear definition of effects and related consequences. It could be seen, that main strategic targets are linked in almost all cases to technical performance indicators, sometimes together with general performance indicators or financial performance indicators. Financial performance indicators are relevant for budgetary aspects only.
- In the public sector the main targets are justified in countries with developed economies by regulation or technical assessment and sometimes in combination with other processes, while in countries with developing economies, the main targets are justified by technical assessment combined with an iterative process and sometimes by regulations. In the private sector, the strategic targets are generally justified by regulation and technical assessment subject to the performance requirement of their contracts.
- The horizon of such strategies differs between 0.5 to 4 years for the short term programme, between 3 to 10 years for the medium term and between 10 to 30 years for the long term view. In the public sector of developed countries long term horizons of up to 50 years were found.

Strategic targets and requirements are the basis for an objective assessment of asset management processes, where a comparison between the targets (objectives) and the actual situation (described by specific performance indicators, which were based on performance monitoring) takes precedence. To what extent such targets and requirements can be exceeded under given preconditions (e.g. limited budget) is often a significant question in the assessment process. If the objectives cannot be met within a certain time frame, an adjustment of these targets should be discussed and agreed.
4. APPLICATION OF CROSS ASSET OPTIMISATION

4.1. Introduction

Holistic asset management has become a standard in many countries worldwide. One of the key tasks for such asset management processes is an improved and optimized coordination of all maintenance activities on the different sub-assets (pavements, bridges, tunnels, roadside furniture, earthwork assets, etc.) according to the expectations and requirements of different stakeholders - road users, road operators, road owners and other affected parties. It is a complex process which needs flexible and adaptable methods, the experience of the road owners and operators and finally a clear definition of the stakeholders’ requirements in form of strategic targets (e.g. provide the best services on the road network, reduce the number of fatalities, having smooth roads, etc.) and asset specific targets (e.g. technical).

Based on the comprehensive investigation within the Trans-European ENR research project PROCROSS [2] a distinction between the following general methods of cross-asset management optimisation was conducted:

1. bottom-up approach;
2. top-down approach;
3. combination of bottom-up and top-down.

With regard to PROCROSS all approaches are valid and consistent in finding an optimum (best) 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 (best) solution is identified and how the translation of strategic targets to technical parameters (especially on object level) is done. A brief description of the different approaches identified by PROCROSS is given below.

4.1.1. Bottom-up approach by PROCROSS [2]

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 analyzed 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. To find an optimum (best) solution, the preconditions (set by the road authority 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, the Bottom-up-process is well established and strongly supported by sophisticated management tools. Many road authorities are organised according to asset-related tasks, so that this approach fits to asset specific management processes.
4.1.2. Top-down approach by PROCROSS

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. 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 budget or fund, 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 centralised 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.

4.1.3 Combination of Bottom-up and Top-down by PROCROSS

In many road authorities a combination of Bottom-up and Top-down approaches is applied in practice. Strategic targets and requirements are defined by the government or the head of the road authority and are compared with the results from the technical assessment of single assets on the object level. The key issue of this solution is to bring the strategic preconditions in coincidence with the technical needs.

In those road authorities, where the combination of Bottom-up and Top-down is used to a wide extent, cross-asset maintenance treatment strategies will be carried out on a level which is situated between the strategic and the object level. This level defines the maintenance activities in so-called “projects”, “schemes” or “planning”, which are essentially an aggregation of the (technical) maintenance needs of the different assets. In most cases this is where strategic preconditions are recognized. However, the projects or schemes are mostly in objection to the view of the object level and can cause conflicts between the strategic department and different technical branches. One of the main reasons for this is the method for the prioritisation of projects or schemes, which is mainly carried out on simple ranking and not on a network-wide optimisation.

4.2. Good practice from public sector

The interview analysis comes to the following conclusions:

- In most cases the top-down and bottom-up approach is used. However, in some cases bottom-up is mentioned for pavements.
- In countries with developed economies cross asset management processes are mainly used for coordination and partly for prioritisation. In only one administration were they also used for optimisation. In countries with developing economies cross asset management processes is applied in all investigated administrations for coordination and for prioritisation. In only one administration was it also used for optimisation and in one further case it was under development for optimisation.
**4.2. Road asset management in developed and developing countries**

- Road administrations in developed countries make ranking/combining of cross asset maintenance treatments mainly by a value management process and sometimes by mapping and/or workshops. Only one administration uses an optimisation tool, as mentioned above. In countries with developing economies, ranking /combining of the cross asset maintenance treatments is in most cases under development and in most cases value management processes are envisaged.

- Barriers for the implementation of cross asset management are many. Lack of harmonised scales is mentioned most often, followed to a lesser extent by lack of tools, lack of data and information, complexity, organisational structure and lack of motivation from experts. In comparison to developed countries, countries with developing economies list problems with organisational structure, lack of data and complexity as barriers for the implementation of cross asset management.

In many countries cross asset management becomes an important issue in the context of asset management. The combination of Bottom-up and Top-down offers a flexible and adequate solution and allows for integration of (general) strategic targets into the decision making processes. An objective assessment of all assets is the basis for such an approach. Although optimisation procedures are under development or in test phases, the prioritisation of projects by using engineering judgement and value management processes is state of the art in countries with developed economies.

### 4.3. Good practice in private sector

For the private sector the following conclusions can be listed:

- In all agencies the top-down and bottom-up approach is used for decisions.
- The cross asset management process is used for coordination and prioritisation, an optimisation procedure is under development in some agencies, but is not yet active.
- Ranking/combining of the cross asset maintenance treatments is achieved by mapping – partially combined with workshops – in most cases. Value management is also used.
- There are fewer reported barriers for the implementation of cross asset management than mentioned in the reports from the public sector. The most common barriers appear to be complexity, lack of data and the organisational structure.

There are no big differences between the public and the private sector. As already mentioned, cross asset management is also an important issue on concessions. The combining of maintenance needs is essential in maximising road availability which is directly related to income (toll, avoidance of penalties, etc.).

### 4.4. Cross asset management and optimisation

As described in the previous chapters, holistic asset management has become a standard in many countries worldwide. The periodical collection of data in form of measurements and visual inspections on pavements and bridges is state of the art in developed countries as well as in countries with developing economies and is the basis for extensions into other assets. On concessions in particular, the extent of data collection and monitoring covers most of the assets to be taken into account within asset management (subject to the type and scope of the contract).
Most of the processes are technically driven by asset specific analysis. Cross asset management will be carried out by using engineering judgment and assessment procedures. Almost no road administration runs an optimisation of maintenance treatments over different assets, taking into account strategic targets and objectives for the whole network. Although these strategic targets are defined in the form of strategic papers, a clear and repeatable connection to technical indicators (of asset elements or properties) is missing to a wide extent. The interviews showed, that missing data, organisational structures, the complexity of the problem, and the compatibility of asset specific indicators are the main barriers for cross asset management optimisation. Thus, the combination of maintenance needs of different assets by using unified indicators derived from strategic targets and objectives (policy) is not the state of the art in asset management in the majority of road administration at the moment.

As already mentioned, cross asset management is mainly based on engineering judgment and assessment at project level, where the maintenance needs of different objects (of different assets) will be merged to maintenance projects (business cases) and finally to a construction programme, taking into account general requirements, which are derived from the strategic targets and objectives. The consequence of this approach can be a suboptimal solution, where the effects and finally the benefits are lower in comparison to a solution including network-level optimisation. Illustration 2, which was developed within the ENR-Project PROCROSS, tries to draw an asset-independent management framework as a base for a cross asset management structure.

For cross asset optimisation of asset specific maintenance strategies the following process-requirements can be listed:

- comprehensive data management;
- unified assessment of all assets in accordance with the strategic targets and requirements (translation of strategic targets into technical indicators);
- organisational structure, which enables an easy merging of the maintenance needs of different assets.

The discussion during the interviews showed, that many road administration are planning or implementing a holistic asset management framework. Maintenance needs, which are derived from asset specific analysis, will be no longer the final result but, they will be an input for a strategic assessment process, including different aspects of the whole asset management framework (technical, environmental, social, sustainability, availability, etc.). The benefit of such an approach can be summarised as follows:
• improvement of the availability of the road network by improved coordination of asset specific maintenance treatments;
• increase of traffic safety by reducing the number of maintenance sites;
• reduction of maintenance risk from a network point of view (not only from a technical, asset-specific point of view);
• reduction of maintenance costs and number of maintenance sites as well as an increase of maintenance productivity (parallel maintenance treatments on different asset within the same site);
• reduction of negative impacts to neighbours and the environment by reducing the number of maintenance sites and the total duration of traffic disturbances during the whole life-cycle of a road section;
• easy integration of external factors into the decision process (corridors, seasonal influences, events, etc.);
• avoidance of extensive network constraints caused by maintenance treatment on parallel roads or on detours at the same time;
• clarity on the achievement of the strategic targets and objectives;
• improvement of communication within the road administration (within technical level but also from technical to strategic level);
• better marketing of road infrastructure asset management to policy makers and the public.

Most of the benefits can be achieved by asset specific assessment procedures without network level optimisation. However, cross asset management derives a benefit from a more holistic point of view, where asset specific maintenance needs are an integrated part of an asset management process, which is oriented to different stakeholder needs and expectations.

4.5. Risk management as part of cross asset optimisation

According to ISO 55000 [3] risk management is integral part of asset management. There are several authorities that use risk management as an input variable in the development of plans and the resulting business case. This can either be on network level or object level.

Risk management as part of the business case seems to have started in the Anglo-Saxon parts of the world. These countries are believed to have the most developed approach, although there is room for improvement. Risk, as part of the business case optimisation, is mostly limited to cost drivers such as, structures (e.g. bridges, tunnels), pavements and in some cases traffic management systems. Methods used are:

• Risk register
  Listing risks, control mechanisms and planning period.
• Risk assessment tool
  Includes a risk register and also optimisation algorithms and/or common sense. Another approach is the use of asset valuation.

Countries tend to develop risk management plans and strategies first for the civil structures such as tunnels, bridges, overpasses, slopes. The main focus is user safety and service level.
5. DEFINITION AND DELIVERY OF BUSINESS CASE

5.1. Introduction

Within any organisation – public sector = government, private sector = company – many departments compete for the available budgets. For those that decide where to put the money, it is important to be shown what value for money they will derive from the budget provided. Any budget request should, therefore, best be forwarded as part of a *business case*. Such a business case includes:

- purpose or long term goal;
- assumptions and methods;
- actions and projected results;
- sensitivity and risk analysis;
- recommendations.

Although a business case will normally include several options, one will be recommended. The recommended approach will commonly be related to providing best value for money. Next to this optimal scenario, other scenarios such as “do minimum” and “do something” may also be presented.

5.2. Good practice from public sector

Quite a lot of authorities find themselves competing with other department for funding for the maintenance programme. How much funding is available is part wise a political question. Therefore, the public sector sees the point of submitting a strong business case for its budget, although the term *business case* is not always recognised.

From the interviews it was observed that:

- Using the historic targets and realised achievements with regard to the set goals helps in getting the message across with regard to the results provided for the money spent and therefore become more reliable within the organisation;
- External auditing can help to stress the importance of providing the needed budgets and the reliability of both the calculations as well as the achieved results;
- Documentation of maintenance backlog (both financial as well as condition) helps to stress the message that if not provided with enough funds, in time the condition of the network worsens.

5.3. Good practice in private sector

Also in private sector similar concerns and results can be observed. In addition to the public sector private sector seems to be more interested in continuous control on the effect of works programs on achieved targets. The main reason here is probably related to the way the contracts are defined obliging private sector to provide the client with information on how KPI’s are met.
5.4. Fundamental issues when considering delivery of the business case

5.4.1. Defining the business case – key components

To define an ideal business case using a textbook approach is not feasible. Any business case should relate to the interests of the decision makers and the stakeholders that influence these decision makers. Therefore, any business case is organisation specific.

The influence of stakeholders in the public sector tends to make delivery of a consistent and straightforward business case more complicated than in private sector. The number of (direct) external stakeholders in the private sector tends to be more limited, mostly only to the financial sector (bank) and the client (i.e. government).

The basis for any business case is a future vision. This vision could be related to the organisation, but also to society as a whole (e.g. an ideal society in 30 years from now). From that vision, one can look backward to define the contours of what should be happening now. By applying those contours a work programme can be developed that provides the best fit to the defined vision and probably is likely to deliver best value for money.

Many road authorities have to submit their budget requests within a pre-defined framework and under a number of constraints. Such business case would commonly include the following:

- current asset condition and target asset condition;
- description of the type of maintenance;
- target in terms of level of service (LOS) and forecasted levels of service;
- necessary budget and alternatives;
- consequences of not funding;
- risks as effect on user and stakeholder;
- ability of the organisation to deliver the program.

Common constraints are associated with threshold values that for specific types of work or budgetary conditions.

The business case starts with the definition of the “ideal” work program or strategy. From this ideal work program, alternatives can be developed. These connect mostly to scenario’s resulting in work programs for less money or having effects on specific themes. Alternatives can be developed that favor certain areas, types/classes of roads or treatments that have direct relations to specific themes (e.g. safety). Any scenario should detail the effects of the choices and risks to the own organisation as well as relevant stakeholders.

5.4.2. Business case review

From the interviews conducted, it was concluded that in the public sector business cases are rarely reviewed by external parties (e.g. external consultants or accountants). For the private sector, this seems to be the more common approach. Here the financial institutions commonly require that the business case is reviewed or audited by external consultants and/or accountants. It is believed that external review can give additional credence to the arguments provided in the business case when they are presented to decision makers.
When reviewing the business case attention should be given to:

- quality of underlying data;
- assumptions made in developing the base scenario and alternatives;
- analytical methods used;
- validity of the results of analysis carried out;
- cost parameters used.

The results of the review can be used to finalize the business case.

5.4.3. Delivery of the business case

When delivering a business case, it has to be accepted that the audience does not always take the long term into account. The focus for decision makers can often be on the short and medium term. Therefore, emphasis needs to be given to be should be given the longer term; the audience needs to be made aware of and feel the consequences of their choices.

It is important to try to find a positive note and be consistent with the information provided in previous presentations. Where insufficient funding was provided in the previous period that needs to be emphasised. It is easier to connect to the public’s interest by taking a positive approach. Common elements that have been successful in influencing the decision makers are:

- emphasising the effect on safety levels of the network and objects;
- emphasising the effect on environmental benefits of specific works/projects;
- impact on road condition from the road users point of view;
- impact on legal and political downfall related to specific works/projects;
- resulting from earlier inadequate funding and related financial effects;
- effects of the changing environment (new methods, more traffic, increasing demands of stakeholders, etc.) in which the works have to be executed.

A good presentation (pictures tell more than words or tables) is also essential in delivering a successful business case.

5.4.4. Reporting on business case

When the business case is accepted and budgets are provided to the road authority, regular updates are demanded by politicians on how the budgets are spent and what effects are being realised. Also, within the organisation of the road authority itself, there is a need for regular updates on the realisation of the business case.

Many of the interviewed road authorities showed update frequencies from yearly up to every 4 years. When updating the business case both long term vision as well as current work program are reviewed. Also, the effects of the work, executed during the past period, in terms of relevant parameters are described. Finally, focus points for the new business case are developed.

Updating and reporting on the business case enables a pro-reactive approach to be implemented that tackles problems at an early stage and enables early adaption and change in the planned programme. Therefore, some degree of permanent control between the actual status and targets
can be helpful. Whenever a diversion of targets from strategy is observed, it should be escalated to higher level. If no additional funding is available, milestones and risks should be reviewed, and the budget adjusted on a priority basis for the budget approved.

As most business cases rely on acquired data on asset condition there should be confidence in this data. It is, therefore, important to properly define the goals and demonstrate that the measurements of all indicators are objective and fully transparent.

6. EXECUTING BENCHMARKING

6.1. Introduction

Road authorities experience a growing pressure to optimise the maintenance and operation of road networks. Generally, the road industry is not known to be the most innovative sector. Cost efficiency and productivity increases have been less than in other economic sectors. Commonly, a way to find areas for improvement is by benchmarking one organisation to another. Therefore, many road authorities are challenged to benchmark themselves to neighboring authorities.

From experience it can be concluded that consistent benchmarking with meaningful conclusions is difficult. Many factors affect the results including different data collection methods, different cost allocations, etc. Therefore, results always have to be interpreted and placed in the context of the benchmarking study itself.

6.2. Good practice from public sector

From the questionnaires / interviews only one good practice in the public sector was identified by the Technical Committee. This example is the BEXPRAC study [4] executed by CEDR in Europe. Most interesting in the example – next to the techniques used in the study – was the willingness of European road authorities to share data and reflect on the results.

The CEDR study shows that benchmarking of maintenance costs is a complex matter. It has to be conducted in a structured and detailed way to allow for all the factors that impact costs and efficiency of the road authorities’ organisation and get the results accepted by the organisations that were part of the benchmark.

Another aspect is that for a meaningful benchmark all organisations have to be willing to share data and put effort in the project to explain their data. Accepting data on face-value is not possible, due to all the different accounting methods with regards to costs within the road authorities’ organisations.

6.3. Good practice in private sector

From the questionnaires / interviews no good practice in the private sector was identified by the Technical Committee. During the discussion of this result it was observed that concessionaires within Europe share some data but quite a lot of data is seen as confidential due to the possible competitive advantages. The advantage of sharing data and become more innovative and more effective learning as a sector is not widely seen.
6.4. Fundamentals to be applied when considering benchmarking

Any benchmarking of maintenance costs between networks or road authorities is complex. In order to be relevant and accurate, it has to be conducted thoroughly and to a relatively deep level to take account of the numerous factors that impact maintenance costs.

Benchmarking comparisons can be carried out at a network (or agency level) or at a maintenance activity level. The following factors potentially impact maintenance costs and the need to be considered or rationalised for any benchmarking to be meaningful. These factors can have varying influence at a network or activity level:

- relative maintenance standards adopted by the agency (including condition targets, intervention criteria and response times);
- consistent definition of the activities that are in scope;
- consistent definition of the costs that are included;
- relative climate, rainfall or amount of snow where the activity is carried out;
- type of subgrade and terrain;
- travel times involved in undertaking works;
- quality of the subgrade and materials used in the pavement construction which can impact the regularity of maintenance actions;
- restrictions in accessing the network (e.g. night work only);
- local environmental constraints and approvals required;
- availability of materials and cartage distances;
- traffic control requirements for works;
- traffic loading and allowable axle loadings;
- age of the assets;
- asset content of a network (e.g. amount of bridges, tunnels, lanes);
- traffic intensity.

In the BEXPRAC study carried out in Europe an extensive effort was made to compare / benchmark the maintenance costs across several road authorities. Some interesting aspects were learned from the study.

The BEXPRAC study indicated that in order to be relevant benchmarking has to:

- take into account the distinctive profile of each operated network;
- cover the real-world experience implemented at operational level;
- guarantee the homogeneity and exhaustiveness of scopes for external and internal costs related to maintenance and operation;
- consider that accounting rules and practices can differ significantly from one network to another.

To provide relevance the BEXPRAC project used two approaches in the benchmarking exercise:
• A macroscopic or macro module (top-down approach), which sought to:
  – Compare the overall costs of operation and maintenance in the participating authority for each considered network as a whole, including (depending on data availability) a breakdown of charges per large task blocks (e.g. routine maintenance, routine operation, winter service, traffic management, large repairs, and improvement works).
  – Explain some of the differences by comparing the distinctive profiles of the networks (by applying the same pertinent segmentation for each network and analysing cost sensitivity to network profiles) and the overall levels of service provided.
• A microscopic or micro module (bottom-up approach), which sought to:
  – compare actual performance levels on a limited range of small-scale subsets in some of the countries;
  – identify the best field practices in road maintenance and operation on the basis of the same observations.

This might not have been the only methodology that could have been used. However, the approach of having a top-down as well as bottom-up approach gives substance to explaining differences observed. What is to be analysed as part of the two approaches can be defined given the specific situation in which the benchmarking study is executed.

In the BEXPRAC study each country was analysed on:

• A special “roads selection”, which means an arbitrary selection of road subsets (either a choice of specific itineraries, or the networks administered by a choice of field units, or a choice of contractor-managed local networks).
• A pertinent segmentation of each country’s selection based on network profiles in order to compare comparable entities.

Both complemented each other: through a refined comparison of practices, the micro module provided a clarification and explanation of the differences revealed at macro level. The macro module provided a comprehensive and structured reference framework (ground rules and lessons learnt, self-evident facts and proven statements) which could help each road authority to draw up its own strategy or policy and possibly facilitate budget negotiations.

In the BEXPRAC study it was shown that when considering expenses some “rules” have to be observed:

1. Ensure the exhaustiveness of analysed expenditure items;
2. Pay particular attention to:
   – whether VAT is included or not, including different VAT percentages in different countries;
   – the accurate distinction between: (a) maintenance and operating costs (consumption) and (b) investments;
   – the asset depreciation and appropriate depreciation periods when applicable (or, alternatively, rental values);
   – whether overhead costs are included or not;
   – whether social security contributions paid by the employer on salaries are included or not.

From the BEXPRAC study the following conclusions were drawn:
• It is difficult to collect information on road maintenance and operational costs in a way that allowed for comparisons between countries.
• Despite the application of strict definitions of costs and road maintenance and operation tasks, the differences in the data collected prohibit clear conclusions on efficiency levels.
• Nevertheless, the survey gives some indications of the reasons for differences between the countries participating in the survey.

7. CONCLUSIONS

The purpose of this report is to provide users with information on good practice in budgetary assessment and optimisation of maintenance strategies as part of the overall management of road assets. Related to the objectives set in chapter 1.2 and the discussion of the results of the interviews and the findings the following conclusions are given as a recommendation for an improved or better asset management of road infrastructure assets:

Good practice in budget assessment

• Many road authorities have some sort of long term strategic plan that relates to many performance indicators. This long term strategic plan is relevant to the prioritisation in budgetary allocation. The strategic plan is discussed both on management as well as “political” levels.
• From the interviews it was observed that all road authorities face constraints in definition of the budgets. Constraints are either related to budget or qualities to be delivered or both. Also the extension of road network and/or changes in assets within the network results in a constraint on the budget. A way of coping with the budgetary constraints is to present choices related to the strategic plan. One of the approaches is using business cases presenting both the ideal situation as well as alternative strategies in showing the expected results and consequences. Consequences to be shown with respect to spending, resulting qualities and/or risks.

Strategic targets and requirements

• Strategic targets and requirements are important for a repeatable and objective asset management process. In particular, the comparison of the actual situation with these targets has an essential impact of any decisions in the maintenance process. Nevertheless, strategic targets and requirements has set to a level, which could be achieved under the given constraints, coming from the financial, the organisational and other (external) preconditions and situations.
• Strategic targets and requirements should be defined at the least for safety, comfort and structural issues. An easy and reproducible process for monitoring and assessment against those targets should be implemented.

Combination of maintenance needs (cross asset management)

• The combination of maintenance needs of different road infrastructure assets into a harmonized maintenance or construction program enables to reduce the negative effects on the users, the neighbours, the environment and other stakeholders to a high extent. Thus, it is important to provide and assess the asset specific data (inventory, condition, etc.) and maintenance needs in a cross asset specific form, where engineering judgement and assessment is possible and the strategic targets and requirements can be included.
• A combination of bottom-up and top-down approach is the recommended procedure.
• Most countries currently use cross asset management for coordination and prioritisation. Most road administrations and concessionaires are using engineering judgement while developing an optimisation process. The main difficulty they are facing is complexity of the task to build a universal ranking scale for all assets allowing for a holistic process.

**Good practice in detailed accounting on budget allocation**

• There is a tendency within the road authorities to move from the “technical” asset management plan to a more detailed argumentative version that relates to strategic targets and the public interests. Some road authorities already use an explicit business case in the accounting of the budget allocation and results derived from it related to the strategies. Also the use of external auditing when reporting on the results delivered is starting to become more used.

• The technical committee envisages a detailed business case approach as the way forward in relating the performance of the asset management organisation to the public interests and therefore also the politicians making the final decisions in allocating budgets within the countries government. For private concessionaires such a business case approach is more common due to the nature of these organisations.

**Application of risk management**

• Risk management should be an integrated part of business cases in asset management. The assessment of risk, based on the probability and consequence of failures, enables a better understanding of the decisions and their effects in asset management.

• Risk management should be included on object (project) level as well as on network level, where the effects of maintenance activities on the whole network (e.g. closure of an important network link) has to be considered.

**Complications and challenges when benchmarking**

• Many road authorities have an interest in knowing where they stand in performance related to other authorities. In general benchmarking is seen as the technique to be used. But from the interviews no useful data was found on the techniques to do a *simple* benchmarking study. Many aspects influence the results and should be accounted for when delivering the results of a benchmark.

• Within Europe an extensive benchmarking study was made “BEXPRAC”. Although some conclusions could be drawn on efficiency of the respective organisations it was also shown that many uncertainties were related to the results. Differences in asset base but also the way costs are accounted within the organisations are relevant when dealing with benchmarking results.
PART B: RESULTS FROM THE INTERVIEWS

8. INTERVIEW SETUP AND APPROACH

8.1. Development of the questionnaire

Early on in the cycle, the Technical Committee decided to conduct interviews (desk studies) as a means of collecting information for the tasks assigned to the working groups 1 and 2. To structure the interviews, a joint questionnaire was prepared. The questionnaire was then used as the basis for conducting interviews. It was decided to carry out interviews with public road authorities and private concessionaires. The interviews were focused on developed countries and developing countries worldwide.

The main objective of the interviews was to gather information on how road agencies or private concessionaires:

- develop strategic targets for their road assets,
- manage (combine) maintenance needs for various road assets on object level,
- prepare business cases for funding of maintenance of assets and/or;
- optimise maintenance budgets across road assets within available funding (cross optimisation).

The initial intention was to develop good case studies from the information collected in the interviews. However, eventually it was decided not to develop specific case studies, but instead to use the results in the current report.

8.2. Guideline for the Interviews

Interviews were generally conducted by Committee members with asset management experts of public road authorities or private concessionaires. The interviewee(s) were required to have knowledge on the development of strategic targets of asset management and to be able to give an overview about the asset specific approach of asset management. Furthermore, it was important that the interviewee(s) to have information available about the combination of asset specific maintenance needs of projects or schemes.

For the preparation of the interview a “Guideline for the Interviews” was prepared for the interviewees and submitted to interviewees in advance, so that all parties were well prepared for answering and discussing the questions. Where necessary, the organisation being interviewed could also be prepared with the range of staff required to provide the advice covered by the questions.

The “Guideline for the Interviews” was provided as Annex A and was structured into six main areas of discussion during the interview as follows:

Table 1 provides an overview of the organisations which were interviewed during the desk-studies. It can be seen, that these consisted of both government/public road administrations (NRAs) as well as a number of private concessionaires. In addition table 1 shows the status of the country (developed or developing economy), the type of the road administration (public, private), and the continent.
8.3. Analysis of the interviews

In the following chapters a summary of the interview results is given in form of a comparison between the different road administrations. The basic information was taken from the completed interview forms and categorised according to the main questions. It has to be stated that the analysis and its output is dependent to a certain extent on the interpretation of the analysts. Thus, it is possible that the summarised interpretation may not be completely representative to the given answers. Detailed information can be gained from the full interview sheets.

9. INTERVIEW RESULTS (TABLES)

9.1. Overview of interviewed road administrations

In Table 2, next page, the general information about the interviewed road administrations is listed. Beside country and name of the organisation, the type of the organisation including their legal status (private, public, other) is shown. The ID (second column) of each interview partner is linked to the detailed information, which is listed in the following chapters.
TABLE 2 – OVERVIEW OF INTERVIEWS

<table>
<thead>
<tr>
<th>Country</th>
<th>ID</th>
<th>Organisation</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina (AR)</td>
<td>AR</td>
<td>Central Corridor Concessionaire S.A.</td>
<td>private</td>
</tr>
<tr>
<td>Australia (AU)</td>
<td>RMS</td>
<td>Roads and Maritime Services Agency within “Transport for NSW”</td>
<td>public</td>
</tr>
<tr>
<td>Australia (AU)</td>
<td>QDTMR</td>
<td>Queensland Department of Transport &amp; Main Roads</td>
<td>public</td>
</tr>
<tr>
<td>Austria (AT)</td>
<td>ASFINAG</td>
<td>Autobahnen und Schnellstrassen- Finanzierungs- Aktiengesellschaft</td>
<td>private</td>
</tr>
<tr>
<td>Belgium (BE-Wallonia)</td>
<td>DGO</td>
<td>Service public de Wallonie, Direction générale opérationnelle des Routes et des Bâtiments</td>
<td>public</td>
</tr>
<tr>
<td>Canada (CA)</td>
<td>ALBT</td>
<td>Alberta Transportation</td>
<td>public</td>
</tr>
<tr>
<td>Canada (CA)</td>
<td>BCMT</td>
<td>British Columbia Ministry of Transportation</td>
<td>public</td>
</tr>
<tr>
<td>Canada (CA)</td>
<td>ONMT</td>
<td>Ontario Ministry of Transportation</td>
<td>public</td>
</tr>
<tr>
<td>Chile (CL)</td>
<td>NDR</td>
<td>National Directorate of Roads (NDR)</td>
<td>public</td>
</tr>
<tr>
<td>China (CN)</td>
<td>SDHB</td>
<td>Shandong Provincial Highway Administration Bureau (SDHB)</td>
<td>public</td>
</tr>
<tr>
<td>Estonia (EE)</td>
<td>ERA</td>
<td>Estonian Road Administration</td>
<td>public</td>
</tr>
<tr>
<td>France (FR)</td>
<td>DIR Est</td>
<td>France, part of the toll free national road network</td>
<td>public</td>
</tr>
<tr>
<td>France (FR)</td>
<td>DI T3</td>
<td>France, part of the toll free national road network</td>
<td>public</td>
</tr>
<tr>
<td>France (FR)</td>
<td>COF</td>
<td>COFIROUTE</td>
<td>private</td>
</tr>
<tr>
<td>Germany (DE)</td>
<td>BAV</td>
<td>Federal State of Bavaria, Building Authority at the Bavarian Ministry of the Interior - Bavarian Road Administration</td>
<td>public</td>
</tr>
<tr>
<td>Korea (KR)</td>
<td>KEC</td>
<td>Korea Expressway Corporation</td>
<td>public³</td>
</tr>
<tr>
<td>Malaysia (MY)</td>
<td>JKR PK</td>
<td>Perak Public Works Department</td>
<td>public</td>
</tr>
<tr>
<td>Malaysia (MY)</td>
<td>MYCON</td>
<td>Roadcare (M) Sdn Bhd, Belati Wangsa (M) Sdn Bhd, Selia Selenggara Selatan Sdn Bhd. Three Companies awarded with a 15 years Concession by the Government to maintain all Federal roads within the Peninsular of Malaysia.</td>
<td>private</td>
</tr>
<tr>
<td>Malaysia (MY)</td>
<td>PWD</td>
<td>Road Facilities Maintenance Division Public Work Department (PWD) Head Quarters, Kuala Lumpur</td>
<td>public</td>
</tr>
<tr>
<td>Mexico (MX)</td>
<td>GDR</td>
<td>General Directorate of Roads Maintenance, Secretariat of Communications and Transport</td>
<td>public</td>
</tr>
<tr>
<td>Namibia (NAM)</td>
<td>NAM-RA</td>
<td>Roads Authority</td>
<td>public</td>
</tr>
<tr>
<td>Northern Ireland (UK)</td>
<td>NIRS</td>
<td>Northern Ireland Road Service</td>
<td>public</td>
</tr>
<tr>
<td>Norway (NO)</td>
<td>NPRA</td>
<td>Norwegian Public Roads Administration – NPRA (Statens vegvesen) is responsible for the planning, construction and operation of the national and county road networks, for vehicle inspection and requirement, driver training and licensing. On matters of national roads the NPRA is under the direction of the Ministry of Transport and Communications, on those related to county roads the Regional Director is subordinated the county legislature.</td>
<td>public</td>
</tr>
<tr>
<td>Poland (PL)</td>
<td>GDNRM</td>
<td>General Directorate for National Roads and Motorway</td>
<td>public</td>
</tr>
<tr>
<td>Scotland (UK)</td>
<td>M6</td>
<td>Autolink Concessionaires (M6) PLC</td>
<td>private</td>
</tr>
<tr>
<td>Slovenia (SI)</td>
<td>DARS</td>
<td>DARS d.d., Motorway Company in the Republic of Slovenia</td>
<td>private</td>
</tr>
<tr>
<td>Slovenia (SI)</td>
<td>SRA</td>
<td>Slovenian Roads Agency</td>
<td>public</td>
</tr>
<tr>
<td>Sweden</td>
<td>STA</td>
<td>Swedish Transport Administration</td>
<td>public</td>
</tr>
<tr>
<td>United Kingdom (UK)</td>
<td>HA</td>
<td>Highways Agency (The Highways Agency is an Executive Agency of the UK Department for Transport (DfT), and is responsible for operating, maintaining and improving the strategic road network in England on behalf of the Secretary of State for Transport.)</td>
<td>public</td>
</tr>
</tbody>
</table>

³ In the following tables, KEC is included in the category of « concessionaires ».
9.2. Results of interviews

In the following tables the different information, which was collected during the interviews with public road administrations in developed countries, public road administrations in countries with developing economy and concessionaires (private sector) are shown as an overview. The tables enable a direct comparison within and between these 3 different categories and have been used as a basis for the analysis in the previous chapters (Part A).

9.2.1. Basic Information

*Table 3* provides an overview about the responsibilities on the different types of road network (expressed by length in [km]).

![Table 3 – Information about the responsibilities on different road networks](image)

9.2.2. Strategic targets, indicators and addressing of stakeholders

One of the main questions during the interviews focused on strategic maintenance targets and objectives (or service levels), which were used in the asset management processes on the different levels. Targets, objectives or service levels are defined usually by the management of the road authority or the ministry of transportation, like quality, safety, sustainability, financing, availability, etc. *Table 4, next page.* gives an overview about different categories of strategic targets, objectives or service levels, which have been addressed from the interviewed road administrations.
The strategic targets, objectives and service levels can be linked to different types of performance indicators, which can be finally translated into specific thresholds and limits. In table 5 the different strategic performance indicators are categorized into the groups “General” (G), “Technical” (T) and “Financial” (F).
Within Table 6 the categorisation of justification for each target, objective or level of service is shown in form of an overview, using the following target categories from the previous tables.

\[ \text{Table 6 – Justification of strategic targets, objectives and service levels} \]

Once a target, objective or service level or target has been “justified”, the budget required to meet the requirements has to be determined.
Table 7 focuses on the main processes used for supporting the evaluation or assessment of the needed budget to meet the requirements.

Table 7 – Approach to determine the budget required to meet the target

The horizon of the strategic targets can be taken from the following table 8.

Table 8 – Horizon of strategic targets, objectives and service levels

Within a strategic maintenance program different stakeholders will be addressed. In table 9 a list of stakeholders – according to the PIARC definition – is given and shows which stakeholders have be addressed by the different road administrations.
9.2.3. Asset monitoring and assessment

A decisive factor for the whole asset management process is the data and information to be collected from the different assets of the road network. With regard to different types of data collections Table 10 gives an overview how the different assets are monitored or inspected.

The measurement and/or inspections are used on the one hand as an essential input for the maintenance planning and on the other hand to justify the target achievement. Table 11 gives an overview about the reaction of the road administration if the targets, objectives or levels of service will not be achieved.
In many road administration the integration of strategic targets, objectives or levels of service into the object level needs a translation of general key performance indicators into technical or asset specific indicators. Table 12 gives an overview about the integration of strategic targets, objectives or levels of service into the asset specific maintenance processes (object level).

### 9.2.4. Maintenance business case

This chapter of the interviews focuses on the implementation of a maintenance business case into the asset management process as a basis for funding the maintenance program. Table 13 gives an overview about the type, target (addressee) and the interval for the business case within the interviewed road administrations.
With regard to the type of reporting, different information has to be transferred. In Table 14 the key information and components of the business case are categorised in form of a comparison.

![Table 14 – Key information and components of business case](image)

A key factor for the evaluation of successful business cases are the aspects or specific arguments in influencing budget allocations. Table 15 provides a categorised list of success aspects and arguments, which were collected during the interviews.

![Table 15 – Aspects and arguments of successful business cases](image)
9.2.5. Cross asset management

One of the main questions within the interviews focuses on cross asset management and cross asset management procedures. As already described, cross asset management is the combination of maintenance needs of single asset into a comprehensive asset management approach. Based on 3 categories of cross asset management (top-down, bottom-up, top-down and bottom-up) Table 16 gives an overview of the different approaches in the different road administrations.

<table>
<thead>
<tr>
<th>Country</th>
<th>Developed countries (public)</th>
<th>Top-down</th>
<th>Bottom-up</th>
<th>Top-down and bottom-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>A2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>B2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 16 – Cross asset management approaches

There are different possibilities to combine the maintenance needs of single asset or sub-assets into a comprehensive maintenance program, taking into account the strategic targets, objective or service levels. Based on the information collected, the combination processes could be categorized generally into “Coordination”, “Prioritisation” or “Optimisation”. Table 17 gives an overview of the different coordination processes within the interviewed road administrations.

<table>
<thead>
<tr>
<th>Country</th>
<th>Developed countries (public)</th>
<th>Coordination</th>
<th>Prioritisation</th>
<th>Optimisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>A2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>B2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 17 – Coordination processes

To get a priority of cross asset maintenance treatment strategies (= coordinated asset specific maintenance treatments) leads finally to the maintenance program. Thus, different tools and procedures can be implemented and applied in practice. Table 18, next page, gives an overview about the status of advanced tools and processes for the prioritisation within the different interviewed road administrations.
An overview about the integration of risk and risk analysis into the asset management process can be taken from table 19.

Different barriers can be a hindrance for the implementation of a holistic asset management approach or cross asset management procedures. Table 20, next page, shows a list of different barriers and problems for the implementation of cross asset management within the interviewed road administrations.
<table>
<thead>
<tr>
<th>Developed countries (public)</th>
<th>Countries with developing economy (public)</th>
<th>Concessionaires</th>
</tr>
</thead>
</table>
| Organisation
| Lack of data and information
| Complexity
| Organisational structure
| Willingness of experts or decision makers
| Lack of resources
| Communication
| Merging of non-consolidated scales
| Financial aspects
| Education

Table 20 – Barriers for the implementation of cross asset management
10. BIBLIOGRAPHY / REFERENCES

The following references were used in the actual report:


[4] BEXPRAC - Benchmarking of expenditures and practices of maintenance and operation. CEDR, Conferences of European Directors of Road BEXPRAC Group, Belgium, March 2010

In addition, the following actual literature is related to the objectives and topics of the actual report:


[25] SOLMINIHAC TAMPIER, HERNÁN E. “Gestión de Infraestructura Vial” (Road Infrastructure Management), Catholic University of Chile Editions, 2001


