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Life cycle costs and NRAs

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Investigation of the application of LCC principles by selected NRAs

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LIST OF ABBREVIATIONS

AM	Asset Management
ANAS	Azienda Nazionale Autostrade e Strade (the Italian national road authority)
ASTRA	Bundesamt für Strassen (the Swiss national road authority)
BEXPRAC	**B**enchmarking of **ex**penditures and **prac**tices of maintenance and operation
CEDR	**C**onference of **E**uropean **D**irectors of **R**oads/**C**onférence **E**uropéenne des **D**irecteurs des **R**outes
CFO	chief financial officer
DBFM	design build finance manage
DGC	Direcciòn Nacional de Carreteras (the Spanish national road authority)
DIR	Direction des infrastructures régionale (French regional road authorities)
DIT	Direction des Infrastructures de transport (the French national road authority)
DSS	Decision Support System
IAM IS	Integrated Asset Management Information System
IQOA	Image Qualité des Ouvrages d'Art
IQRN	Image Qualité du Réseau National
IRI	International Roughness Index
IT	information technology
ITS	intelligent transport systems
KPI	key performance indicator
LCC	life cycle cost
LCCA	life cycle cost analysis
LoS	level of service
NAMP	National Asset Management Plan
NRA	National Road Authority (or Administration)
O&M/M&O	maintenance and operation
PAM	programme asset management
PI	performance indicators
PIARC	World Road Association
PPP	public private partnership
RWS	Rijkswaterstaat (the National Dutch Water and Road Authority)
SFC	sideway force coefficient
SLA	Service Level Agreement
SP2	CEDR's second Strategic Plan (2009–13)
SP3	CEDR's third Strategic Plan (2013–17)
TG	technical group/task group

1 DEFINITION OF THE ISSUE AND MAIN RESULTS

1.1 Background

The **B**enchmark of **Ex**penditures and **Prac**tices of maintenance and operation (BEXPRAC) was launched on the initiative of France during CEDR's Governing Board (GB) meeting in Ljubljana in 2008. Thirteen NRAs volunteered to participate. The BEXPRAC report was approved by the Governing Board in Riga in September 2010 and was then published on CEDR's public website at the end of that year.

The BEXPRAC study provided an important tool for comparing the criteria and guidelines for operating the road network within the framework of European NRAs. Decision-makers need data, information, and analysis to develop relevant and valuable transport policies and programmes for their country. Moreover, the data can be used to reveal how people, goods, and vehicles move through the system and measure the impact of social, economic, and environmental factors on the system's performance.

Although the results of the BEXPRAC project were important, a major critical issue emerged when the figures were actually used for comparison and policy purposes: the criteria used by the NRAs to define the items that represent the different components of the road network are not homogeneous. Consequently, the value of the results of BEXPRAC was very high in absolute terms, but subject to various caveats in relative terms. The average cost per km of different components of road operation and management is a useful result, provided that the criteria on which the data collection is based reflect the same categories and variables. This in turn may depend on other factors, such as the level of service supplied by the different NRAs, which may consist of a different set of activities with the same designation (e.g. 'winter operations' or 'grass removal').

Moreover, if we move from ordinary maintenance to periodical and extraordinary maintenance, definitions and criteria may differ greatly between NRAs. The expected life of the road assets and the guidelines for maintaining and amortising them differ from state to state. Even within the same NRA, accounting and technical categories may differ even though they refer to the same assets or asset components.

In conclusion, it was decided that the benchmark on the different policies implemented by the NRAs in road operation had to be subjected to an in-depth analysis of how life cycle costs (LCC) are defined, how they are reflected in the accounting system, and how they are allocated to the various stretches of the road network in the participating countries. LCC is usually (although not always) the first step towards creating a comprehensive asset management (AM) approach. This is an integrated system in which all operational activities foreseen for the management of the road are clearly defined—from the technical, economic, and financial points of view—and prioritised. This allows the actual value of the assets that contribute to the determination of the road classification to be calculated and periodically updated.

The mandate was given for a task group to analyse the LCC and AM approaches adopted by a group of NRAs that are part of CEDR, to analyse the data collected, and to synthesise the lessons learned in order to get to a common set of definitions and a common core system. The ultimate goal is to formulate a workable best practice guide for the adoption of a broad LCC and AM approach. Depending on the results of this deepening of the context of BEXPRAC, a second international study similar to BEXPRAC could be launched with a view to getting to a fully workable set of comparable operational data.

1.2 Definition of the issues and main results achieved

In recent years, national road authorities (NRAs) in Europe have been making efforts to strike a balance between **growing transportation demand**, **ageing infrastructures**, and **diminishing resources**. Any **technical and economic methodology** capable of balancing asset effectiveness and efficient resource allocation is considered essential for all attempts to cope with the challenges ahead.

To this end, **asset management** (AM) provides a **systematic process** for maintaining, upgrading, and operating physical assets in a cost-effective manner using a series of road management procedures and tools. Most importantly, asset management provides decision-makers with **a framework for both short- and long-term planning**.

Note: the shareholders are generally the owners of the road agency, which may be a government authority at national or regional level or private investors in case of a PPP; stakeholders are all those interested or affected by the road, i.e. users, neighbours, and associations.

Asset management is based on a set of processes and tools for network management and for relationships with shareholders and stakeholders. It enables:

- ✓ **the optimisation of the 'total cost of ownership' relating to the management of road infrastructures;**
- ✓ **funding to be secured for routine and preventive maintenance with a multi-year investment plan based on a set of levels of service (LoS);**
- ✓ **the prioritisation of preventive maintenance and maintenance operations based on the current state of roads, risk analyses, life cycle costs, and projected levels of service.**

Life cycle cost analysis (LCCA) is an evaluation technique within the asset management framework that is used to support **investment decisions**.

LCCA is applied when a road authority is planning a new investment and seeks to determine **the lowest life cycle cost project** (i.e. the most cost-effective project) that will allow it to **reach its investment goals**. LCCA enables decision-makers to make sure that final project selection is based not only on the lowest investment costs, but also **on all properly discounted future costs during the project's life cycle.**

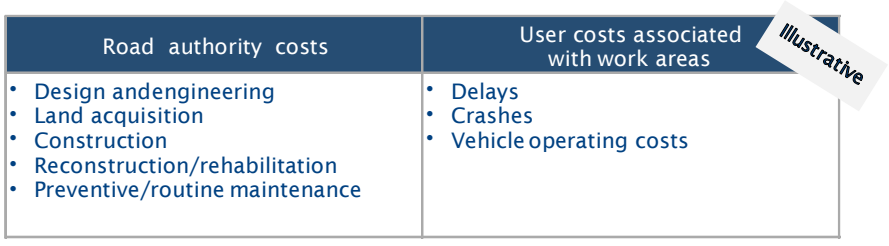


Figure 1: Example of the costs considered in LCCA

All relevant costs that arise throughout the life of a possible alternative (not only the initial expenditures) may be taken into account, including supplementary investments, major repairs, and on-going maintenance.

- ✓ **The objective of this investigation of selected NRAs is to understand how AM/LCC principles are reflected within accounting systems, in terms of life cycle cost definitions, accounting principles, and cost attribution within the road infrastructure.**
- ✓ **Seven NRAs (France, Italy, the Netherlands, Slovenia, Spain, Switzerland, and the United Kingdom) were interviewed directly with the support of a comprehensive questionnaire based on asset management standards and lessons learned from previous reports.**
- ✓ **The seven NRAs were divided into two groups: Group 1 included the NRAs that have already implemented a comprehensive AM/LCC system (the Netherlands, Switzerland, United Kingdom). Group 2 included the NRAs that have started to develop such an approach, but have not yet completed the process (France, Italy, Slovenia, Spain).**
- ✓ **The main results are:**
  - **a common core system for AM/LCC to be deployed by NRAs;**
  - **recommendations and a workable guide for implementing the core system within each NRA;**
  - **common items and divergences in AM between NRAs;**
  - **key evidence and best practice from involved NRAs.**

First of all, as a result of the BEXPRAC study, there is a **homogeneous way of defining life cycle costs** within the panel of participating countries. Such costs include the following task blocks:

- **routine operations** *(e.g. traffic management, patrolling, tunnel operations, etc.);*
- **routine maintenance** *(e.g. winter services activities, road signs and markings, etc.);*
- **preventive maintenance** *(e.g. maintenance on the full width of a roadway, bridge barrier replacement, etc.);*
- **network improvement and development** *(e.g. global upgrading of a whole itinerary, replacement of whole roadways, structures, bridges, crossroads; bridge replacement, etc.).*

There are some **differences in terms of ownership and management**. In Spain, for instance, traffic management operations within routine operations are performed by another entity; in England, routine operations, routine maintenance, and preventive maintenance are performed by single concessionaries for specific geographical areas; in Italy, several contracts relating to specific routine operation activities or preventive maintenance interventions exist within the same geographical area.

However the **above classification**, which is 'standardised' from a technical point of view, **diverges when it comes to NRAs' accounting processes and systems**, particularly when it comes to **balance sheets**.

- ✓ **The seven NRAs on the panel do not usually capitalise routine operations and routine maintenance expenditures.**
- ✓ **Preventive maintenance expenditures are capitalised by half of the NRAs on the panel. However, significant differences between NRAs exist when it comes to the criteria and calculation methods applied. These differences relate mainly to the NRA's 'legal structure' (company, agency, department in a ministry, etc.) and to country-specific rules and regulations.**
- ✓ **Network improvement and development are capitalised by almost all NRAs.**

	NRAs Group 1			NRAs Group 2			
	the Netherlands	Switzerland	United Kingdom	France	Italy	Spain	Slovenia
Routine operations	no	no	no	no	no	no	no
Routine maintenance	no	no	no (*)	no	no	no	no
Preventive maintenance	no	YES	YES	no	YES	no	no
Network improvement & development	no	YES	YES	YES	YES	YES	no

(*) Few routine maintenance activities are capitalised by the HA (e.g. bridges: parapet painting, cleaning, small repairs)

Figure 2: The capitalisation of expenditures by NRAs

Moreover, there are other **differences regarding** the **capitalisation of expenditures by NRAs**:

- ***Asset evaluation goals.*** Assets are **evaluated by NRAs for different purposes relating to specific objectives**: for NRAs' balance sheets, for the state's balance sheets, for financial reporting, for asset management, and for internal purposes as well.
- ***Asset evaluation criteria.*** **Two main methodologies** are used by NRAs to assess asset values: **historical cost** and **gross replacement cost. Most NRAs apply the historical cost methodology,** with some differences in terms of 'starting date', while the **UK adopts the gross replacement cost** methodology (currently evolving from a greenfield to a brownfield one). The **Netherlands does not consider asset value**.

- ***Type of costs taken into account.*** **Expenditures relating to completed works are monitored by all NRAs; internal resources** costs are only monitored by a few of them (e.g. Italy). Most NRAs capitalise completed works only (e.g. Switzerland and France), while others (e.g. Italy) also include on-going works starting with the design phase.
- ***Depreciation and amortisation criteria.*** **Each NRA uses specific amortisation criteria**, shifting from an **asset-type life cycle** (Switzerland, United Kingdom, and France) to an **asset-type life cycle combined with concession period** (Italy) or to no amortisation (Spain), depending on the legal structure of the NRA, the asset evaluation goals, and criteria (as explained above).

✓ **Significant differences in expenditure capitalisation procedures and methodologies used by NRAs make benchmarking extremely difficult as long as a common European framework is not established.**

Currently, **without a common core system**, surveys may produce only **partial and non-comparable results**, **like the one in the following graph**, where the value of NRAs' assets given in balance sheets or financial reports is linked to the overall number of km of roads managed.

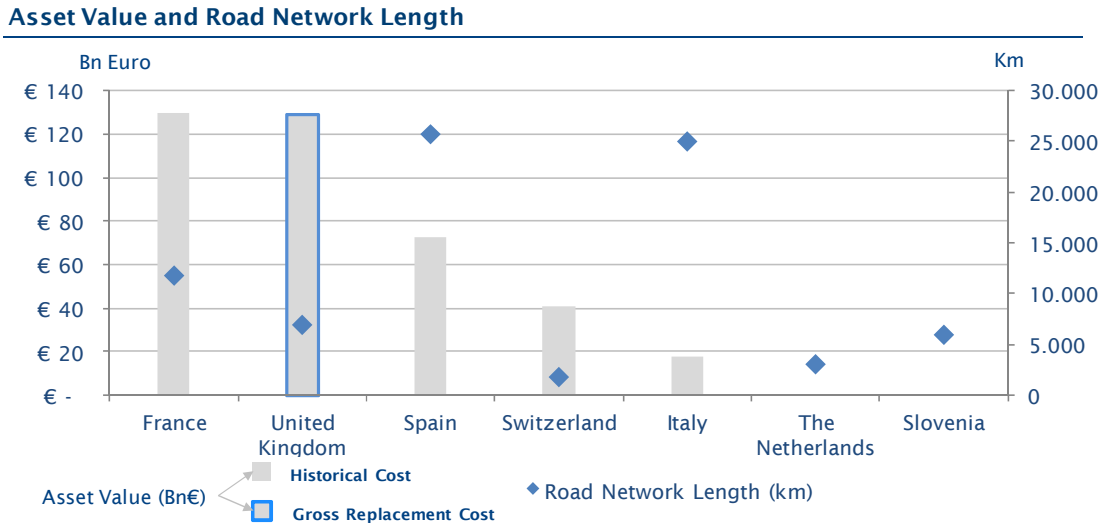


Figure 3: Asset value of the seven NRAs on the panel – comparison of different accounting principles and methodologies

Such differences are **even more relevant** when the investigation focuses on a small part of the road network managed by each NRA, such as **a single stretch of road**. **Accounting and IT systems** should give NRAs an exact **knowledge of past and future expenditures** on the single asset objects/components involved in order to:

- support **maintenance planning processes** on a life cycle analysis basis;
- perform a **valuation of the whole road network** as the sum of the values of elementary blocks, such as the value of a single road stretch.

These accounting and IT systems currently provide this **knowledge to several NRAs** (Switzerland, the Netherlands, Italy). However, detailed data is **partly used in planning processes as well as in asset evaluation methodologies**.

Furthermore for a specific road stretch, because of accounting principles, asset evaluation criteria and available IT tools, there might be only the expenditures related to preventive maintenance and network improvements done in recent years (i.e. since 2002 in Italy or since 1992 in Spain). This gives a situation where on a 50-km road segment, the related value of the assets include only tracked expenditures for only 20 km out of the 50 km. In these cases, a gross replacement cost (*brownfield-based*) evaluation criteria might be advisable in order to bridge potential gaps in asset value.

- ✓ **Taking into account the above-mentioned highlights and the findings obtained from NRAs early experiences, an LCC/AM core system has been devised.**
- ✓ **The evaluation of LCC/AM comprises several intertwined steps, both on the technical side and on the economic side (management control, accounting, financial).**

These steps seek to develop a **full-range LCC model** to be integrated into the AM framework and shall be used **for specific road stretches** with increasing levels of detail, from asset types to asset objects and asset elements.

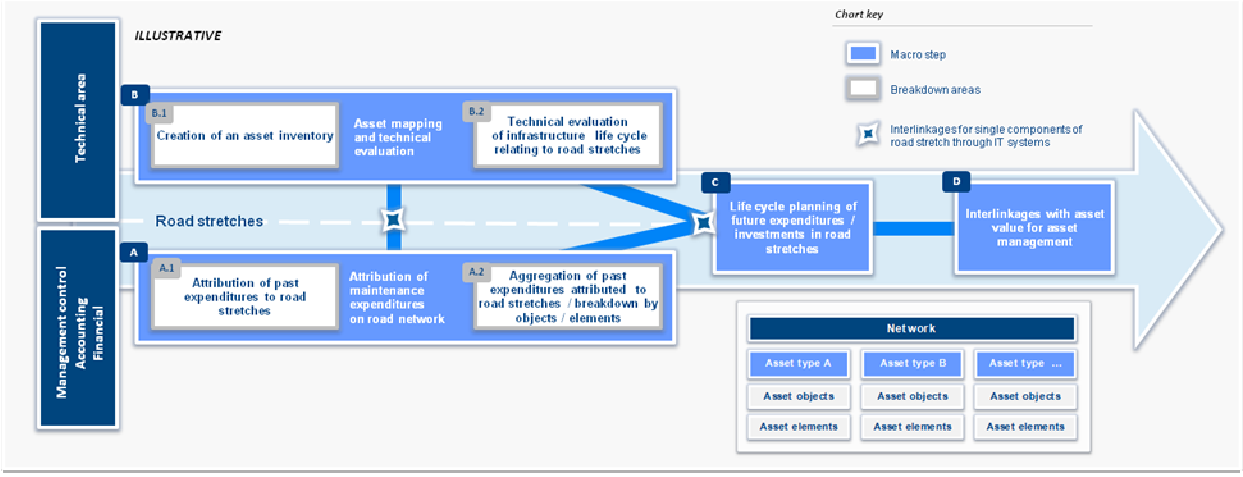


Figure 4: LCC/AM core system

To ensure that the adoption of this framework is beneficial, **each of the following steps** has to be managed coherently by the organisation:

- **management of the technical side:** through an asset inventory (which is constantly updated) and a periodical technical evaluation of the state of the road network infrastructure, along with the level of service provided on the roads, and with the evaluation of risk and needs for safety, etc.;

- **management of the economic side:** through a more detailed attribution of global maintenance expenditures to road stretches, to get an overview of the total maintenance expenditures for single objects on the road network.

✓ **By taking some key preliminary steps ('A' and 'B' of the common core system), NRAs can plan future expenditures for road stretches on the basis of past expenditures and projections stemming from infrastructure life cycles.**

✓ **This step represents the key link between the technical and the economic area.**

Accounting interlinkages with the overall asset value enable the identification of potential increases/decreases in the overall asset value (e.g. through historical cost of investments relating to single road stretches), allowing NRAs to reap the full benefits of an asset management system.

The **implementation of an overall asset management system built on life cycle cost** principles in an NRA's accounting systems as described above offers **NRAs as a whole**—NRA managers, shareholders, and stakeholders alike—several benefits, mainly in terms of **better strategies, informed decision-making processes and procedures, and enhanced communication** with shareholders and third parties.

As highlighted in the results of the study, benefits can be expected in terms of both actual and expected results of the implementation of an AM/LCC system. The **major categories of benefits** are:

- improved **overall knowledge of the status and the comprehensive value of the assets**, detailed according to road stretches, as well as the planning of future maintenance needs; this information facilitates management decisions;
- **a comprehensive decision-making framework**, ensuring consistency among all major areas of NRA corporate management: accounting, finance, and technology;
- **relevant and objective information based on asset value that is accessible to all participants in the decision-making process**, which helps improve information flows and relationships with shareholders on the basis of detailed factual information about road stretches;
- improved **understanding of the value created by the NRA in the long term**, measured in terms of the overall increase/decrease in asset value;
- improved control of maintenance expenditures, which gives NRAs greater knowledge of a specific section of the road network being maintained and the relevant time-frame. Clear **interlinkages with expected LoS** and provision of a goal-driven system;
- increased capability of **prioritisation of future expenditures/investments** (both initial investment and future maintenance expenditures on renewal or safety) on the basis of the defined framework, taking into consideration all the intertwined elements from different management areas; consideration of maintenance options or combinations of optimum options in order to reach expected LoS and management objectives;

- enhanced **evaluation of the risks involved** in the maintenance of road stretches, also using 'what-if' and sensitivity analysis tools and outlining the 'cost of doing nothing' for NRAs and their stakeholders;
- potential for **enhanced dialogue and negotiation with shareholders** based on relevant and comprehensive information, risk analysis, prioritisation, and interlinkages with LoS;
- potentially **improved 'buy-in' from shareholders and other decision-making bodies**, especially in terms of **future budget allowances**;
- availability of **communication tools with facts and figures** that are tailor-made to suit stakeholders' needs (e.g. road users, local communities, involved third parties);
- effective **benchmarking and best practice dissemination of NRAs' strategies and activities,** based on the overall value of the network or for comparable road stretches.

The **process of implementing** the AM/LCC core system, which is typically implemented in a step-by-step **approach**, might allow some benefits to be reaped before others, depending on the path followed.

However, **some intermediate results will be available immediately** during the implementation process, in particular, allowing more informed managerial decisions to be made on key maintenance issues and the on-going dialogue and communication with shareholders to be improved.

The **positions of the NRAs on the panel regarding the defined core system** varied considerably. This diversified outlook can be summed up as follows:

- ✓ **In general terms, several approaches to AM/LCC management have been identified. There is no single unifying model for all NRAs (*no 'one size fits all' model*).**
- ✓ **No NRA in Group 1 feels that it has completed its development path towards the LCC/AM model.**
- ✓ **Almost all NRAs have identified the improvement of their asset management systems as a key stream to be activated within the organisation.**
- ✓ **There is some general attribution of past expenditures to road stretches (Group 1 and one case in Group 2), but other steps are not uniformly distributed.**
- ✓ **Not all Group 1 NRAs uniformly conduct a comprehensive evaluation of assets with accounting interlinkages to AM/LCC in order to evaluate the effects of NRA policies on the value of the assets.**

A breakdown analysis allows the areas of the LCC/AM core system covered by each NRA and the key findings concerning each model to be highlighted. As illustrated in the figure below, **no NRA on the panel covers all LCC/AM core system steps yet**:

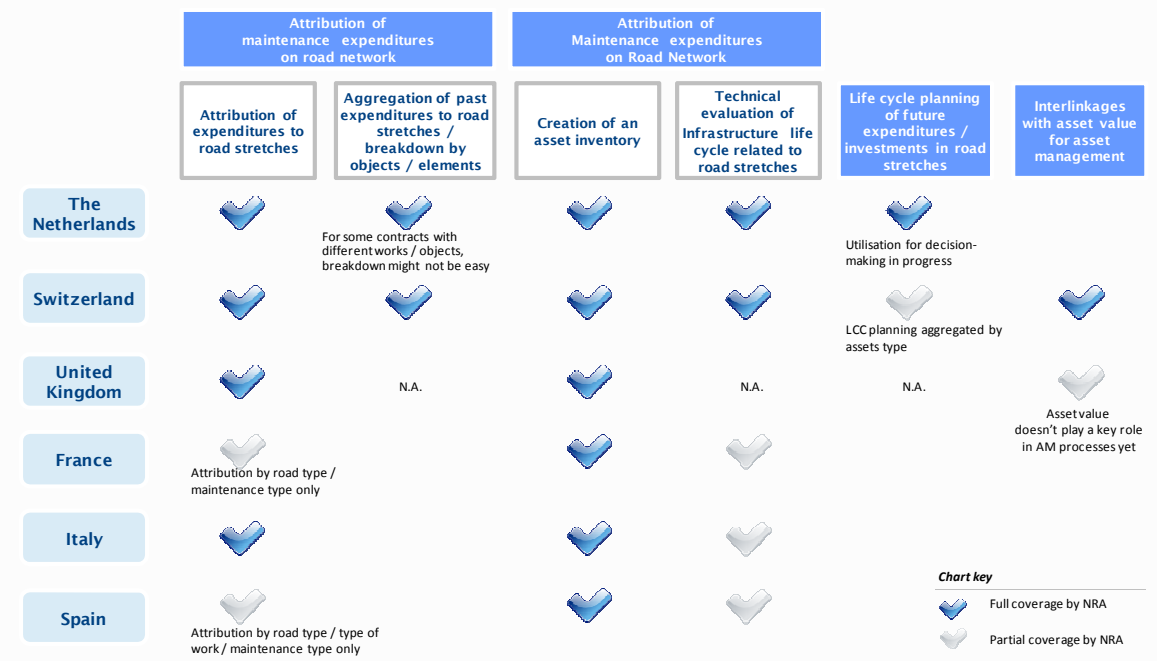


Figure 5: Outlook from NRAs on the panel

On the basis of the results of the present survey—where no single unifying model emerged, and several approaches to LCC/AM were identified—it is advisable to proceed further, in subsequent streams of analysis, to the evaluation and endorsement of a **potential single unifying model** that might enable the full consideration of LCCA within a wide-ranging asset management framework.

✓ **The proposed model of an LCC/AM core system, based on the steps highlighted in the present document, is regarded as a general starting point since it builds comprehensively on previous projects/reports, on the experiences of more advanced NRAs that have been interviewed, and on the responses to the questionnaires from a consistent panel of CEDR member country representatives.**

On the basis of this **core system**, an overall path towards the implementation of an asset management that is inclusive of LCC shall be agreed for NRAs as a whole. In doing so, for specific areas, **some existing best practices or illustrative experiences** outlined in this document **shall be considered**, in particular those relating to the more advanced countries in CEDR TG3 Group 1.

Furthermore, **it is recommended that consideration be taken of the overall value of network assets** as an aggregation of all road stretches on the network, since this value constitutes the one major element that bridges the gaps between accounting, finance, and technology.

The proposed methodology is that of the **historical cost approach** for establishing infrastructure values. Only in those cases where historical cost information is not available (especially over a long period of time) are proxy estimates using the **current replacement cost** based on the actual conditions of the assets—i.e. '***brownfield***'—used instead.

The definition of a unifying model shall consider an **average time of implementation** for all major steps, also considering both intertwined steps that might have development areas in common and best practice dissemination.

- ✓ **Pioneering NRAs noted that the development of advanced LCC/AM models typically involved a time-span of approximately three to five years.**
- ✓ **By capitalising on previous experiences and by putting in place organisational mechanisms (e.g. inter-functional committees, MBO) to support this change, these times could be reduced for subsequent developments.**
- ✓ **Moreover, the value of the network's assets, which is key to AM/LCC systems, could be determined within one year, or even in a shorter timeframe, depending on the availability of information within NRAs.**

Potential steps forward to implement the results of the present survey might therefore be:

- implementation of the common **LCC/AM** core system in potentially all NRAs based on specific preconditions to be reached by the NRAs depending on their current advancement, the steps they have already taken, and the availability of their data;
- assessment of **legal and fiscal legislation** in each member country in order to **identify ways of harmonising evaluation and accounting criteria between NRAs**, properly taking into account each NRA's 'legal structure';
- in the long-term, identification of ways of **performing preventive maintenance and pavements renewals** on main European road itineraries (e.g. 'Trans-European corridors') based on a common economic framework.

2 EVIDENCE GATHERED FROM THE ANALYSIS OF NRAs

The analysis took the form of both **a questionnaire sent to NRAs** and **direct interviews with NRA professionals** and covered several areas linked to LCC/AM.

The areas of analysis were divided up as follows.

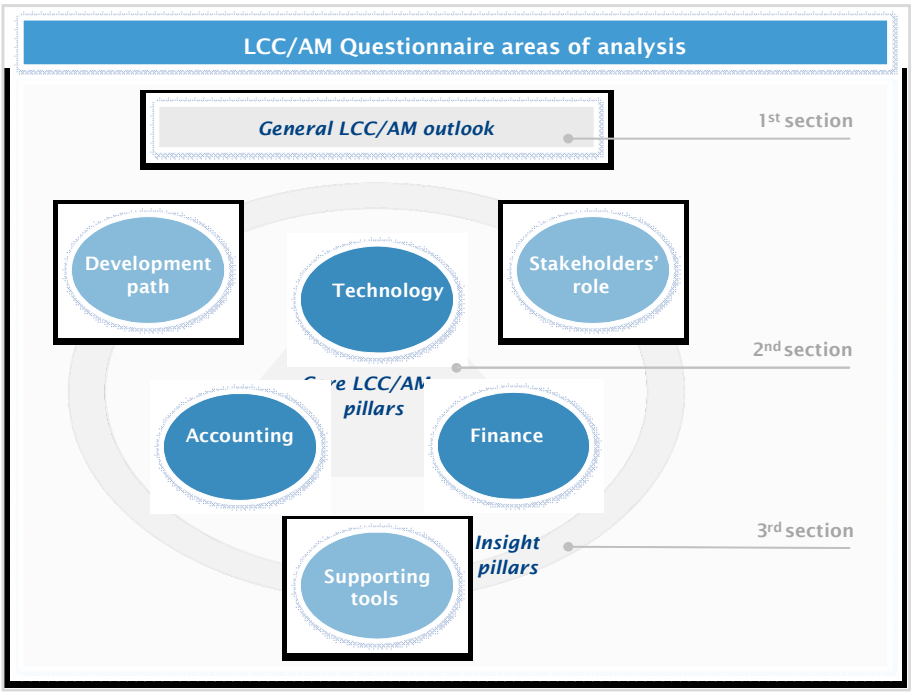


Figure 6: LCC/AM areas of analysis

- **General LCC/AM outlook:** general elements that define the overall current outlook for the interviewed NRAs
- **LCC/AM pillars:** relevant elements relating to a comprehensive model adopted by the NRA along the following core areas:
  - accounting
  - finance
  - technology
- **Insight pillars:** important, relevant elements relating to areas that help paint a full picture of LCC/AM deployment within NRAs:
  - supporting tools
  - stakeholders' role
  - development path

The overall findings for each area of analysis are presented in the six boxes below.

Accounting

The **attribution of maintenance costs (routine/preventive) to specific road stretches**/segments highlights the different positions adopted by respondents from Group 1 and Group 2, in particular:

- ✓ **All group 1 countries allocate construction costs to specific road stretches** and aggregate later maintenance expenditures to this road stretches (typically with a breakdown by object).
- ✓ In general, **Group 2 countries do not attribute costs to specific road stretches** (only in one case, with no further detailing for an object): an allocation is usually made, mostly on the basis of nature of the road, the type of works, or the nature of maintenance (routine or preventive).

In terms of considering all **past expenditures and future projections** stemming from the infrastructure life cycle to determine overall future expenditures needed for road stretches, Group 1 NRAs conduct these analyses:

- ✓ In one case, it is done at **general level for asset types** (objects are **aggregated** in macro-categories, and aggregated percentage ratios in terms of asset value are set for each asset type for defining economic needs of future interventions).
- ✓ In another, a **comprehensive valuation framework** is defined (i.e. all asset types, all objects, all basic components). The use of this information to steer future decisions is currently **in progress**. For specific contracts, the allocation of costs might be difficult because the contract may contain several different categories of work and may not be structured in accordance with the valuation framework used otherwise by the NRA

A comprehensive evaluation of assets—with accounting interlinkages to AM/LCC in order to evaluate the effects of NRA policies on the value of the assets—is not uniformly conducted by all Group 1 NRAs.

Two out of three countries in Group 1 value their assets, one at historical costs, the other at gross replacement costs. The third has no asset evaluation, neither in the NRA's or in the country's balance sheet.

On the other hand, **Group 2 NRAs record asset values** albeit **for different purposes**: directly in their annual reports, in general state accounting, or for internal purposes only. For these NRAs, asset values are calculated in a general way on the basis of **historical costs**, adding up the value of external works and internal personnel, with the application of depreciation factors, every year.

Finance

The financial means used by NRAs come almost entirely from their shareholders (public budget) or from ad hoc taxes levied on roads users (such as oil taxes). In some cases, there might be minor revenue streams from third parties (private investors for DBFM contracts, European funds) for financing new infrastructure.

No specific financial models for routine/preventive maintenance **have been reported**, neither for Group 1 nor for Group 2 NRAs.

Financial imbalances are not generally considered relevant by the respondents, except in one case.

Both NRAs with larger fund allowances—based on AM/LCC evaluations—and NRAs with lower or fixed allowances do not as a general rule incur financial imbalances. The former group can rely on funds provision based on evaluated assets' needs; while the latter group typically proceed with road works/investments only when financial provisions are made.

Technology

All NRAs are strongly committed to reducing safety risks on their road networks. The estimation of maintenance needs, which is performed by NRAs, is mostly supported by measurements of the deterioration level of infrastructure components.

The **improvement of an asset value does not appear to be a main factor** that influences the development and implementation of the maintenance programmes. The LoS process is not directly linked to the life cycle of infrastructure components.

Supporting tools

Supporting tools provide active support for the evaluations relating to AM/LCC and provide the shareholder with a detailed analysis of the assets.

Group 1 appears to have more advanced management systems for monitoring several maintenance scenarios (such as decision support systems (DSS), scenario analysis tools, forecasts on future development of road infrastructure status).

The scope of supporting tools may vary, depending on the items that are traced, on KPIs, and on specific assets configuration. For instance, KPIs are not treated in the same way (some NRAs—even within Group 1—have not devised a full set of KPIs; in other cases, the KPIs are limited in number).

Shareholders/stakeholders' role

The relationship with the shareholder is key for all NRAs. In particular, those NRAs with more advanced AM/LCC approaches emphasise

- the need for 'transparent' communication with their Ministry,
- the responsibility given to the NRA for the long-term asset management,
- direct and frequent interaction (reports, meetings, co-working on specific tasks, etc.).

The relationship with stakeholders (road users, local communities, environmental associations, etc.) is most intense when defining services to be provided, which are typically information-based, or when developing projects for new roads.

Development path

NRAs seeking to implement a structured AM/LCC approach look to a **medium-term time horizon** (around five years and more to roll out a consistent approach).

The learning path mainly requires the setting-up of channels for **information-sharing and communication** with the ministry, **organisational arrangements** within the NRA (specifically between the technical and economic areas), the re-definition or reconfiguration of **processes, work procedures, tools**, and **key items** to be monitored.

2.1 General LCC/AM outlook

The analysis of the **general LCC/AM outlook**, which was inspired by the PAS55 standard, focuses on developing general elements that define the overall current outlook for the interviewed NRAs that provided information about asset management systems in terms of strategies, objectives, policies, and procedures.

The findings from interviews and questionnaires emphasise that:

- Asset management is **only organisationally structured within Group 1 NRAs**.
- **Aspects of the LCC approach have been adopted by several NRAs** (also from Group 2) in some specific cases only, such as **new developments of large infrastructural investments** (e.g. tunnels, bridges, …).
- In general terms, **several approaches to AM/LCC management were identified**, with no single unifying model for all NRAs (no 'one size fits all' model);
- In particular, the presence of an AM/LCC model is not dependent on key factors, such as the **legal structure** of the NRA (incorporated company, agency, department in a ministry, etc.), whether **assets are capitalised/evaluated** or not, the extent of **financial allowances** by the shareholder, or the **size of the network.**

By way of example, the following table shows the asset management model applied in the Netherlands:

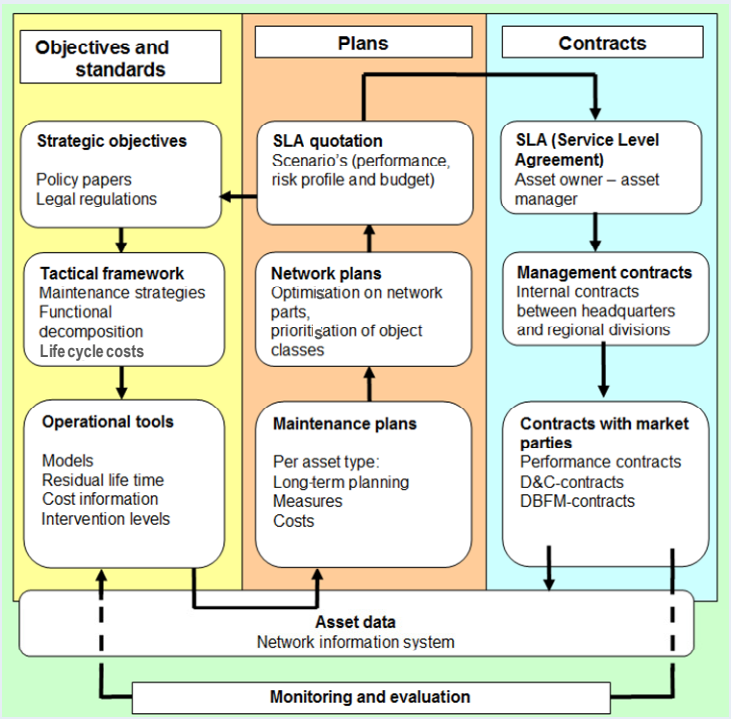
The Netherlands' asset management strategy

At ministry level, a vision of future needs is put in place. This is then translated at agency level (RWS) into a 'network vision'.

RWS has a Programme Asset Management [PAM], which started in 2012. The aim is to improve the coherence of:

- object information (what assets are owned?)
- maintenance planning (when is maintenance performed?)
- risk-based maintenance strategies (how to do maintenance relating to the required performance described in the SLA with the Ministry)
- maintenance contracts (procurement)

Life cycle cost throughout all life cycle phases of the assets



2.2 Technology

The investigation of the **field of technology focuses on how maintenance and operation activities are planned, executed, and monitored by each NRA** and if/how the application of LCC/AM principles influences these processes.

Responses given in interviews and questionnaires show that:

- there is a **strong commitment** among all NRAs to reduce safety risks on their road networks;
- the NRAs estimate the need for maintenance mostly based on the deterioration level measured on the infrastructure components;
- the **improvement of asset value does not appear to be a main factor** that influences the maintenance plans' setting;
- **LoS processes are not directly linked to the life cycle** of infrastructure components.

Different areas of interest were discussed, such as:

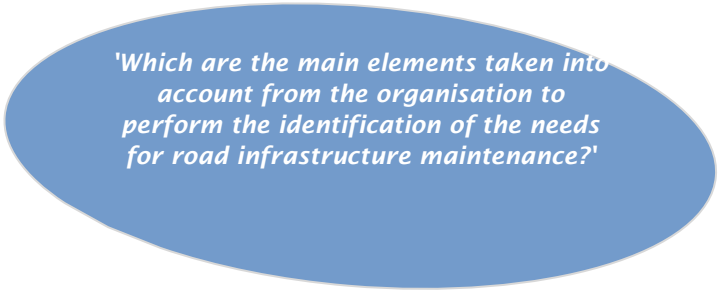
- road infrastructure maintenance needs
- the life span of maintenance plans
- levels of service management
- LCC analysis for maintenance

Concerning **areas of investigation relating to maintenance needs estimation and planning methodology** (as needs of road infrastructure maintenance and the life span of maintenance plan sections), the questions submitted to NRAs sought to consider how maintenance processes are managed by each NRA *(e.g. variables considered during the maintenance needs estimates, prioritisation procedures, life span of the maintenance plan, etc.).*

The questions put to NRAs on the **management of levels of service** sought to investigate the relationship between life cycle cost principles and the decision-making process each NRA applies for road network maintenance planning *(e.g. use of LCC tools to predict or analyse different maintenance scenarios).*

The following section focuses on some questions from the questionnaires and related findings from respondents.

2.2.1 Road infrastructure maintenance needs



Among several variables proposed (e.g. safety risk, levels of service, traffic data, etc.), all NRAs agree that **safety risks** are the primary variable when estimating maintenance needs.

In fact, safety risk is considered the most important parameter for 5 out of 6 participating countries.

All NRAs consider that the deterioration of infrastructure components and the level of service are directly connected. They also consider these criteria to be the second most important for identifying maintenance needs. An overview of priority levels assigned on average over the considered variables is provided in

Figure 7.

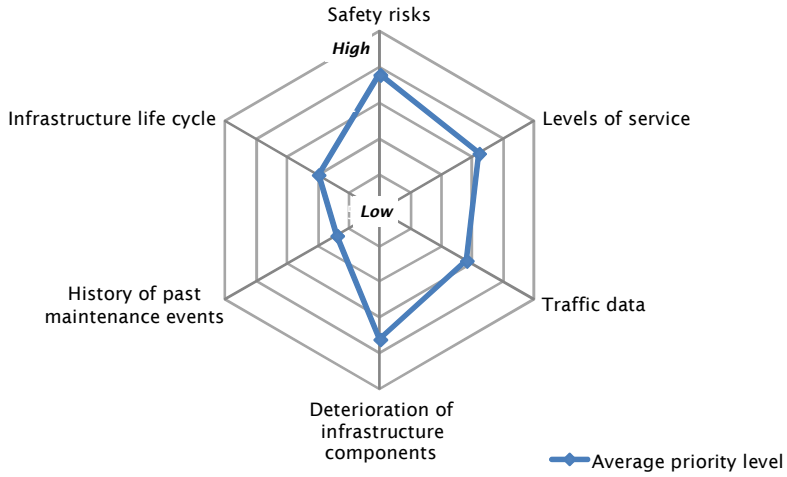


Figure 7: Estimating maintenance needs: most relevant variables considered

Figure 8, which provides a detailed overview of the priority levels assigned to each variable by NRAs, shows that:

- **most of the considered variables are taken into account** by most of participating NRAs;
- the history of past maintenance events is not a high priority for all NRAs;
- NRAs do not agree on the weight of the traffic data variable for maintenance needs identification: only two out of six NRAs consider it a high-priority parameter.

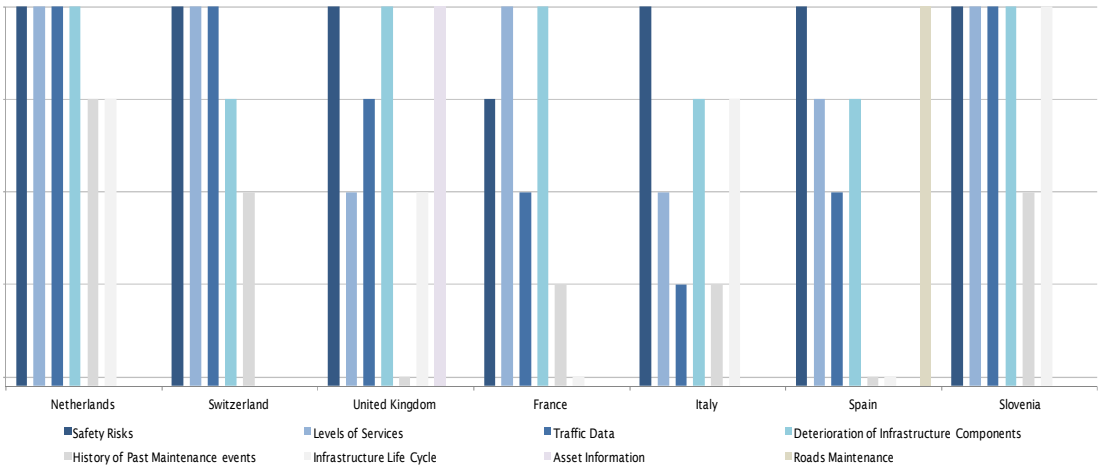


Figure 8: Estimating maintenance needs: priority levels assigned to variables by NRAs

2.2.2 Life span of the maintenance plan

'What is the life span of the multi-year road network maintenance plan?'

Every NRA draws up a comprehensive maintenance plan, taking into account its road network maintenance needs over a certain time horizon.

Based on questionnaire responses, the life span of the maintenance plan depends on its primary scope. In particular, an operational view is achieved with a one-year life span, while a strategic view of the road network is assured by a multi-year plan.

Figure 9 provides an overview of NRAs' maintenance plan life spans, illustrating that:

- **most NRAs (five out of seven) take a short life span** (**1–3 years**) **into consideration**, favouring an operational view on maintenance needs of the road network rather than a strategic one;
- **two out of seven NRAs consider both views**, the operational and the strategic.

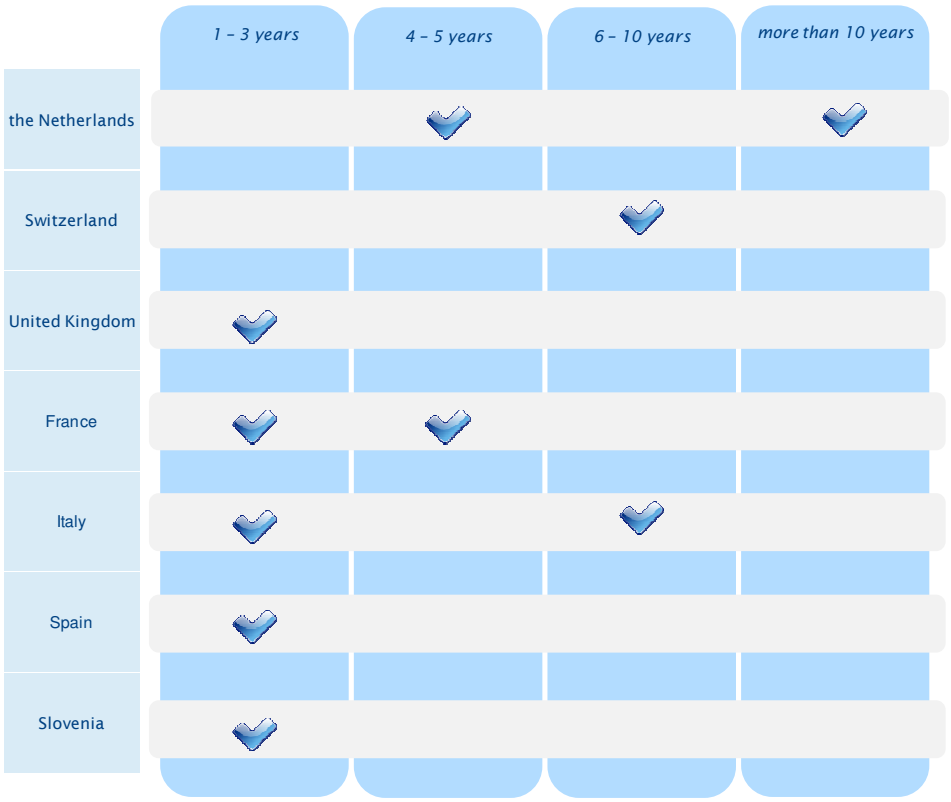


Figure 9: Life span of the maintenance plan: overview

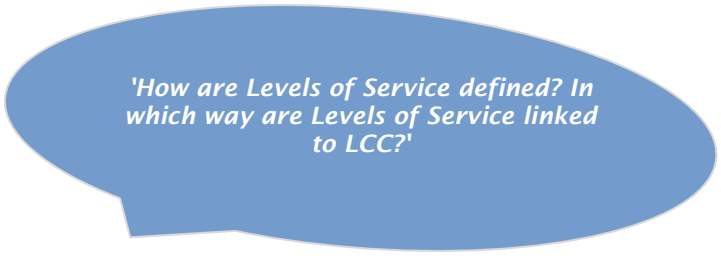
The main key findings for the NRAs in **Group 1** are summed up below.

- **The Netherlands:** a **4-year** maintenance plan is defined on the basis of the SLA, **a 25-year maintenance plan** defines the road network strategic vision.
- **Switzerland**: the life span of the multi-year road network maintenance plan is ten years; it is revised twice a year.
- **United Kingdom:** the **NAMP** (National Asset Management Plan) **is devised each year**, containing an evaluation of the condition of the HA's assets and future approach to maintenance; every three to five years, the HA is subject to a **Government Spending Review.**

The main key findings for the NRAs in **Group 2** are summed up below:

- **France:** the **yearly maintenance plan** is based on road conditions, measured by the **IQRN** indicator (*Image Qualité du Réseau National*) and on the needs expressed by regional offices; a **4–5-year maintenance plan** includes all planned maintenance work on the road network.
- **Italy: the yearly preventive maintenance plan** is based both on the needs expressed by regional offices and on the 10-year maintenance plan that gathers all planned maintenance work for the whole road network.
- **Spain:** there is a **yearly routine maintenance plan**, but there are also plans for specific elements *(barriers, tunnels, pavements, etc.)* that cover **several years of maintenance**, which are considered to be guidelines for the development of shorter-term plans.
- **Slovenia:** the pavement management system carries out a cost-benefit analysis for the subsequent 15 years. It provides maintenance plans for each year covered by the analysis. Because PMS is not yet operational on the whole network, the plan is revised only once.

2.2.3 LoS management



In order to develop an LCC-oriented strategy for managing maintenance needs, a close connection between levels of service and life cycle costs may be envisaged.

Nevertheless, from the responses of the questionnaire, it turns out that NRAs do not yet typically take the life cycle of infrastructure components into account when defining levels of service.

In the Netherlands only, the NRA is starting this connection process by developing an advanced and optimised LCC-oriented maintenance strategy.

NRAs have different approaches to the definition of levels of service.

- **The Netherlands**: LoS are indirectly linked to LCC, using an optimised LCC maintenance strategy **translated into an annual average budget**.
- **Switzerland**: levels of service are defined in **technical guidelines**.

- **United Kingdom**: the levels of service of the HA's assets are monitored annually through the NAMP for pavements and structures assets, geotechnical and drainage assets, technology and lighting assets. Levels of service are **formalised in Managing Agent Contractor** (MAC) contracts.
- **France**: LoS are related to **deterioration levels** of infrastructure components:
  - for **pavement surfaces**, the level of service is characterised by the percentage of pavement surface in good or fair condition, **which must be higher than 85%**;
  - for **bridges**, the level of service is characterised by the percentage of bridges in good or fair condition, **which must be higher than 87%**.
- **Italy**: LoS are related to **routine maintenance and operations services**; there is a specific agreement between ANAS and Ministry of Transportation about the expected LoS.
- **Spain**: LoS are **mostly related to routine maintenance and preventive maintenance**; the calculated parameters are related to both asset physical condition (e.g. IRI - International Roughness Index, deflections, etc.) and data provisioning (e.g. surveillance, winter maintenance, communications in tunnels). Part of the network has been outsourced (first generation highways plan) comprising a length of 1,000 km, having a total of 47 ratios to ensure service levels and predefined desirable state levels.
- **Slovenia**: LoS are defined in the Slovene Technical Specifications (TSC) for **each pavement property**. **All properties are characterised by five condition classes from very good to good, fair, poor and very poor**. Threshold values are defined for those five condition classes. Deterioration models are taken into account in the cost-benefit analyses conducted as part of the pavement management system. When a specific pavement property reaches a poor/very poor condition, a preventive treatment is triggered, costs are calculated, and pavements properties are reset.

"Are the provided Levels of Service monitored by any tool? Does the organisation use any alert system when a specific LOS is under its target?"

Although each NRA has its own methodology for **monitoring levels of service,** the monitoring usually takes the form of activities such as infrastructure inspections, collecting findings, data analysis.

Responses stemming from questionnaire analysis show that these activities are usually supported and facilitated by some kind of dashboards or IT tools.

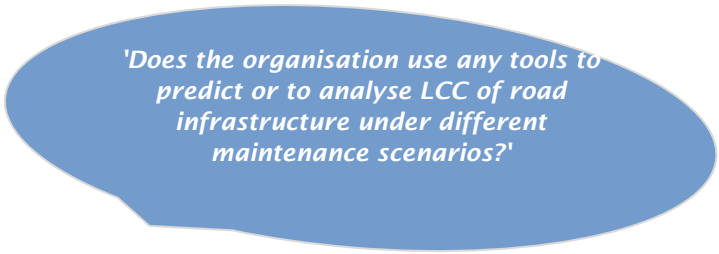
The main findings relating to the investigation of the LoS monitoring process among Group 1 NRAs are outlined in more detail below.

- **The Netherlands**: RWS monitors the LoS provided via a **Network Management Information System** (NIS) that publishes KPI reports every 4 months.
- **Switzerland**: ASTRA has dedicated **tools** (*pavement and bridges, electromechanical elements are in development*) where **inspection results** are stored. Consequently, the management system provides the organisation with an evaluation of asset conditions.
- **United Kingdom**: the Highways Agency does not have a specific tool, but its model ensures that every part of the network is **revised every three years.**

The main findings for Group 2 NRAs are given below.

- **France**: pavement surfaces and bridge ratings are recorded using GIS software. With the help of this software, LoS compliance is evaluated, although there is no alert system in place.
- **Italy**: for some of the services provided (e.g. vegetation care or road signs and road markings) the M&O Department periodically gathers the results of inspections made by its resources and then provides reports on the results. For other services, like infomobility or equipment repair, performance is automatically monitored by regional control rooms through their integrated operating system (**Road Management Tool**).
- **Spain**: there is no specific tool; on-site measurements and supervision of contracts determine when the compliance of a ratio is not met. There is a fixed period during which the value of the ratios is determined: annually for the SFC (sideway force coefficient) and the IRI (International Roughness Index), every 15 months for engineering structures, etc. Once these values have been obtained, the operations to be performed are decided accordingly.
- **Slovenia**: Cyclic measurements of the LoS have been performed since 1995. Annual reports are issued for individual measurements. These reports indicate the road sections that are in poor and very poor condition. The statistics allow condition trend changes to be identified from one cycle of measurements to the next.

2.2.4 LCC analysis for maintenance



When it comes to the adoption of dedicated tools to predict and analyse the LCC of road infrastructure under different maintenance scenarios, NRAs do indeed seem to have different approaches.

The main evidence provided by questionnaire responses show that while NRAs in Group 1 are more oriented towards devising more sophisticated approaches (LCC-oriented approaches), NRAs in Group 2 have not developed yet systems with such functionalities.

The main findings for NRAs in Group 1 are given below.

- **The Netherlands**: RWS has developed a system for analysing different maintenance scenarios for the following infrastructure components: road pavements, bridges, and sluices.
- **Switzerland**: ASTRA uses different management system tools (one for each asset type) to predict the change in the state of the infrastructure for preventive maintenance; ASTRA does not consider routine maintenance in its asset management and for its strategy.
- **United Kingdom**: the Highways Agency has defined its Decision Support System (DSS); this system is used both to support the strategic planning of the whole road network and to define the maintenance scenario for a single infrastructure component.

2.3 Accounting

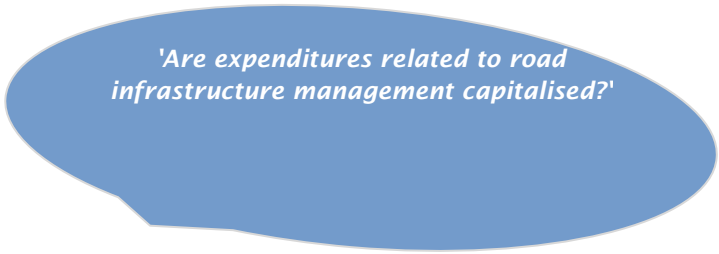
The investigation of the **field of accounting** focused on **how road infrastructure assets and related expenses are considered in the NRAs' accounting systems**.

Different areas of interest were analysed:

- the capitalisation of expenditure relating to road infrastructures;
- network infrastructure assets valuation;
- maintenance expenditure attribution.

The above-mentioned areas of analysis sought to provide an understanding of different accounting methodologies adopted by NRAs and their policies for assets valuation *(e.g. the basis on which asset evaluation is performed)*. Special attention was given to maintenance expenditure attribution on the road network used by NRAs.

2.3.1 Capitalisation of expenditures relating to road infrastructures



The capitalisation of preventive maintenance expenditures is not homogeneously applied by the NRAs analysed. When it comes to the categories identified in the questionnaire (e.g. routine operations, routine and preventive maintenance, network improvement), almost all NRAs apply capitalisation of expenditures relating to network improvement and development. Only in the Netherlands are none of the expenditures considered capitalised; in fact, assets appear neither on the agency's nor on the state's balance sheet.

None of the NRAS capitalise expenditure for routine operations and routine maintenance. The only exception to this rule is the United Kingdom, which capitalises a few routine maintenance activities such as those on bridges (e.g. parapet painting, cleaning, small repairs).

Figure 10 provides an illustration of capitalised expenditures among NRAs.

	NRAs Group 1			NRAs Group 2			
	the Netherlands	Switzerland	United Kingdom	France	Italy	Spain	Slovenia
Routine Operations	no	no	no	no	no	no	no
Routine Maintenance	no	no	no (*)	no	no	no	no
Preventive Maintenance	no	YES	YES	no	YES	no	no
Network improvement & development	no	YES	YES	YES	YES	YES	no

(*) Few routine maintenance activities are capitalised by HA (e.g. Bridges: parapet painting, cleaning, small repair)

Figure 10: The capitalisation of expenditures relating to road infrastructures

2.3.2 Network infrastructure assets valuation

'Concerning network infrastructure assets valuation: on which basis is the valuation performed? On which time frame? Who is in charge of the evaluation?'

Each asset has an economic value relating to the overall road network and it can be calculated either from the original investment cost and subsequent ones, or from the replacement cost.

This section seeks to analyse how NRAs perform asset valuations on their road networks, in which time horizon this calculation is conducted, and how this kind of valuation supports road asset management.

The main findings based on questionnaire responses (see Figure 11) are summed up below :

- **Almost all NRAs perform annual road asset valuations**, applying different valuation methodologies. Most of them calculate asset values on the basis of the **historical cost of road infrastructure**. Only in the United Kingdom is the calculation is based on the gross replacement cost.
- A **comprehensive evaluation of assets—**with accounting interlinkages to AM/LCC in order to evaluate the effects of NRA policies on the value of the assets**—is not uniformly performed** by all Group 1 NRAs.

		NRAs Group 1			NRAs Group 2		
		The Netherlands	Switzerland	United Kingdom	France	Italy	Spain
On which basis is the valuation performed?	Historical cost		✓		✓	✓	✓
	Economic value						
	Gross replacement cost			✓			
During which timing intervals is the road network subject to valuation?	1–5 years			✓	✓	✓	✓
	6–10 years		✓				
Who is in charge of valuation?	AM Department		✓	✓			
	CFO						
	M&O Department					✓	✓
	Other				✓ Government		

Figure 11: Overview of network asset valuations by NRAs

The following tables underline the main findings derived from questionnaire responses, for NRAs in both Group 1 and Group 2 (this piece of information has not been entirely made available in the questionnaire for Slovenia and the benchmark is therefore not available for that country):

	NRAs Group 1		
	The Netherlands	***Switzerland***	***United Kingdom***
Asset valuation methodology	/	• Historical cost	• Gross replacement cost
Goals	/	• Asset management	• Financial reporting
Capitalised expenditures	/	• **Expenditures relating to completed works** (preventive and network improvement and development) • **Internal staff costs** are **not capitalised**	• The **infrastructure asset valuation** is based on a standard cost model • The gross replacement cost is calculated as if providing a replacement asset, on a **'green-field'** site, constructed to modern build standards and then **depreciated to take account of the condition of the network** • Renewal maintenance expenditures on pavement/structures are capitalised
Depreciation criteria	/	• The amortisation time horizon is as follows for major asset types: – Pavement/bridges: 30 years – Tunnels: 50 years – Electromechanical equipment: 10 years	• All parts of the network infrastructure, apart from land, which has an unlimited useful life, are depreciated
Other information	/	• The whole road network is subject to valuation, detailed on single infrastructure object	• The whole road network is subject to valuation

	NRAs Group 2		
	France	***Italy***	***Spain***
Asset valuation methodology	• Historical cost	• Historical cost	• Historical cost
Goals	• State balance sheet	• NRA balance sheet	• Internal purposes only
Capitalised expenditures	• **Expenditures relating to completed** network improvement and development works • **Internal staff costs are not capitalised**	• **Expenditures relating to on-going** preventive and network improvement and development works • **Expenditures relating to completed** preventive and network improvement and development works • **Expenditures linked to design phase for a new construction** • **Internal staff costs directly linked to the construction of an asset are capitalised**	• **The net asset value is calculated, adding up all the investments** that are made each year • It does not take into account the maintenance and operation costs because it is assumed that these maintain the asset value
Depreciation criteria	• Annual depreciation is calculated, depending on the deterioration rate, by the Financial Department upon IQRN and IQOA results. • The amortisation time horizon is as follows for major asset types: – Pavements: 30 years, – Bridges: 100 years.	• The amortisation time horizon is the lower value between the life cycle of each asset type and the remaining years of ANAS' concession (final year is 2032)	• No depreciation is applied to the valuation of assets
Other information	/	• ANAS has been evaluating its road network assets since 2002, but an initial asset value for whole road network has not been calculated	• The Direccion General de Carreteras has been evaluating its road network assets since 1992

The chart in Figure 12 illustrates the asset value in proportion to the road network length for each participating NRA: the 'asset value per road network km' varies widely among NRAs: **since there are major differences in how each NRA capitalises its expenditures, a comprehensive comparative analysis provides little insight**.

The asset value (in billions of euro) is plotted on the primary y-axis and the length (in km) of the road network managed by each NRA on the secondary y-axis. On the x-axis, instead, participating NRAs are placed in descending order of asset value.

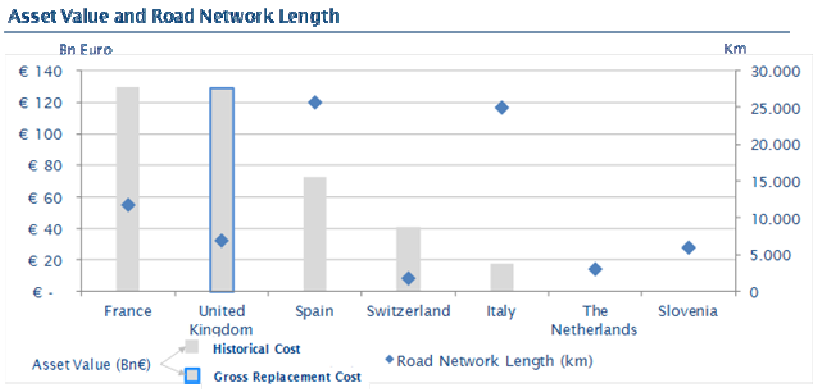
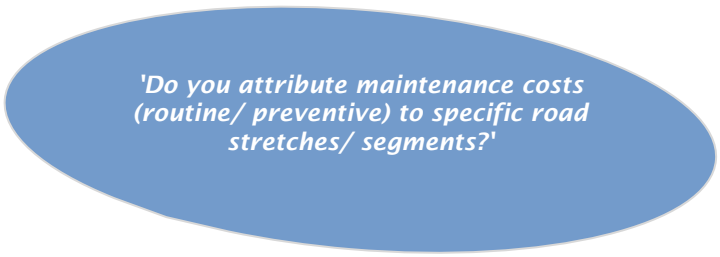


Figure 12: Asset value and road network length

2.3.3 Maintenance expenditure attribution



This objective of this section is to understand how NRAs attribute maintenance expenditures to road assets.

Particular attention is paid to the **attribution of past expenditures to road stretches and how they affect the decision-making process** on the road network for evaluating future expenditures.

Based on analysis results, the attribution of maintenance costs (routine/preventive) to specific road stretches/segments highlights different positions among respondents from Group 1 and Group 2.

As shown in Figure 13, only expenditure attribution to the type of work (routine and preventive maintenance) is provided by all NRAs.

	NRAs Group 1			NRAs Group 2			
	the Netherlands	Switzerland	United Kingdom	France	Italy	Spain	Slovenia
Attribution to type of maintenance works	YES	YES	YES	YES	YES	YES	YES (**)
Attribution to specific road stretches	YES	YES	YES	No	YES	No	YES (**)
Attribution to asset types/single objects	YES	YES	N.A.	YES(*)	No	No	No

(*) France only attributes expenditures to asset types, not to single objects

(**) The attribution of expenditures is performed by Slovenia only for pavement maintenance works executed and over a small portion of road network (10% of total)

Figure 13: Maintenance expenditure attribution by NRAs

The following table provides further information on the expenditure attribution methodology:

NRAs Group 1

The Netherlands – RWS

- **Past expenditures are aggregated** in order to get a complete as-is picture of expenditures on specific road stretches. Post calculations are used to calibrate future cost estimates.
- All past expenditures and **future projections** stemming from infrastructure life cycle are considered to determine **overall future expenditures** needed for road stretches (although it is still difficult to gather and use it as decision information).
- **There have been some difficulties performing breakdown analysis on specific costs** whenever maintenance work on different objects (e.g. road, bridge, viaduct) is executed within one contract.

Switzerland – ASTRA

- For **most objects on the network there is a breakdown in elements** (e.g. 17 elements for bridges); the decision to attribute expenses to specific elements is taken by the person in charge of the type of objects in question, i.e. bridges, tunnels, pavements, ITS, etc.
- **Percentage ratios of asset value for each asset type** (mainly based on historical trends) are provided in order to define **economic needs of future intervention** (percentages may change over the years).

NRAs Group 2

France – Direction des Infrastructures de Transport

- The expenditures are allocated by road category only;
- There is **no attribution of past expenditures to road stretches** / **segments**.

Italy – Anas

- **Aggregation of past expenditures** in order to **get a complete as-is picture of expenditures on those specific road stretches** / **segments**, although available, is not used to predict future expenditure.

Spain – Direccion General de Carreteras

- **Costs are attributed in relation to the type of roads** (e.g. one way or two ways) **and the type of works** (e.g. pavements, signals, routine operations …);
- **Historical costs** are used to make a **new budget** and also to prepare **new plans** (e.g. barriers, pavements, …).

Slovenia - Direkcija Republike Slovenije za ceste

- **Slovenia only attributes expenditures for completed pavement maintenance works** and over a small portion of road network (10% of total), covered by pavement management system.

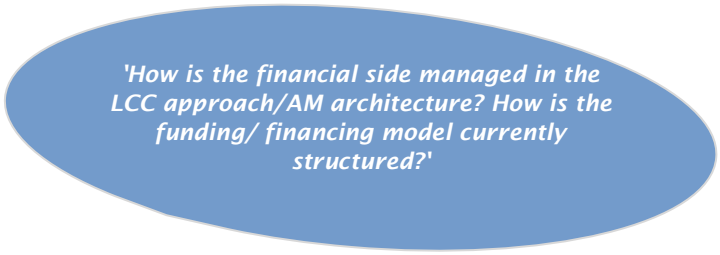
2.4 Finance

The aim of analysing the field of **finance** was to understand how road infrastructure assets and related expenses are considered in NRAs' accounting systems.

Responses given in interviews and questionnaires highlight that:

- **no specific cash planning methodology** for LCC has been devised by NRAs;
- for almost all NRAs, **cash imbalances are not considered relevant issues**.

2.4.1 Funding/financial model



Responses given in the questionnaire relating to funding/ financial models show that **major funds for maintenance are received from the government**.

In a few cases, NRAs receive some funds from other authorities/entities, such as the European Commission.

The main difference to emerge between the NRAs in Group 1 and Group 2 is that the former receives funds from shareholders that are generally in line with requested needs, while the latter defines maintenance priorities on the basis of the funds received from shareholders.

The box below contains an overview of evidence provided in the responses to the questionnaire.

NRAs Group 1

The Netherlands – RWS

- The funding for new infrastructure and maintenance is (still) separate.
- The SLA contains a **budget for new construction [MIRT]** and a separate budget for maintenance.
- The maintenance budget is provided on an annual basis with 4-year service level agreements.
- In addition, a **social cost-benefit analysis** is performed as part of the evaluation.

Switzerland – ASTRA

- The **financing model** for Swiss highways is based on an **oil tax** guaranteed by the Swiss Constitution.
- The **NRA budget** is part of the normal budget of the Swiss Confederation and there are **no terms and conditions** for funding by the shareholder.
- ASTRA has **not devised a special financial model** for AM.

United Kingdom – Highways Agency

- The Highways Agency is subject to **UK Government Spending Reviews** every three to five years.
- Funds for interventions, both pavement renewals and new investments, are available on **a three-year basis**.

NRAs Group 2

France – Direction des Infrastructures de Transport

- **Each year,** on the basis of the agreed maintenance plan, DIT receives funds **from the government** to devote to preventive maintenance for the subsequent year.
- Road network renewal and development campaigns (for example the one conducted for tunnel equipment) are covered by an ad hoc funding stream from the government.
- In case of new investment in the road infrastructure, co-funding mechanisms can be put in place between local entities and government.

Italy – Anas

- Regarding network development and preventive maintenance, approved investments are covered by government funds.
- Regarding **routine maintenance and routine operations**, the annual budget is covered **by revenues from a highway toll fee quota** supplied by national private road concessionaries to Anas.
- Other funding models adopted by Anas are co-funding with regional/local authorities or EU funds.

Spain – Direccion General de Carreteras

- The state provides the funds needed for both programmes in the budget (Building Road infrastructure and Road M&O);
- The funds for financing the highways stem entirely from the state and come from annual budgets;
- **EU** / **EIB funds** used to be **relevant in the period 1995–2008**; works funded by EU are not reflected in the state budget for roads.

Slovenia - Direkcija Republike Slovenije za ceste

- **The Slovenian Roads Agency (SRA)** has an **annual budget** for its road network activities.
- Regarding **pavement maintenance**:
  - **The financial costs of preventive treatments are calculated** (depending on the type of treatment, unit cost, and physical characteristics of the road section). The costs are summarised for every section and for the whole network. The net present value is taken into consideration.
  - The budget for preventive maintenance is defined as being somewhere on a scale ranging from "unlimited" to "zero". The effects of these budgets on the condition of the pavements are calculated.

2.5 Shareholders/stakeholders' role

The aim of examining the **shareholders/stakeholders' role** was to analyse the key features of the institutional relations established for LCC/AM issues between NRA's and stakeholders.

Different areas of interest were analysed during the project:

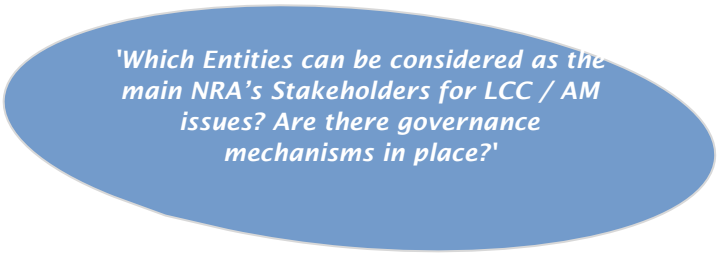
- NRAs shareholders and stakeholders and governance mechanisms;
- channels and means of communication between NRAs and stakeholders.

The focus of the investigation of **NRAs' shareholders and stakeholders and governance mechanisms** was on analysing shareholders' and stakeholders' involvement in the NRA's decision-making process on managing road assets and on indentifying their main requirements. The investigation of **channels and means of communication** is more focused on identifying means of information transmission relating to road assets between each NRA and their shareholders and main stakeholders.

Responses given in interviews and questionnaires show that:

- the **relationship with the shareholder is key for all NRAs** although there are some differences between NRAs in terms of the level of involvement and governance mechanisms;
- **transparency with the shareholder** with regard to maintenance activities can be considered **a key success factor** and a **possible enabler for LCC/AM development**;
- **road users are considered important stakeholders** who have to be kept updated on all information relating to road mobility; some NRAs have **developed dedicated and innovative channels of communications** (e.g. Twitter accounts, customised mobile applications, etc.).

2.5.1 NRAs' shareholders and stakeholders and governance mechanisms



Road infrastructure shareholders/ stakeholders must play a key role in developing an LCC/AM strategy in order to take into account their expectations and needs. Transparency with shareholders appears to enable an LCC/AM strategy.

While the main shareholder is identified as the ministry/government, stakeholders mainly include private operators, road users, and local communities. Road users are of particular interest.

Questionnaire results show that levels of involvement and governance mechanisms differ among NRAs.

The key findings for NRAs in Group 1 are given below.

- **The Netherlands:** most projects include agreements with all local stakeholders involved. Moreover, road users are interviewed before implementation of the project in order to take preventive measures.
- **Switzerland:** there is a strong governance mechanism between Astra and the Swiss government (e.g. scheduled meetings between the ministry/parliament commission and the board of the NRA, ministry approval, and review of the maintenance budget).
- **United Kingdom:** regarding new infrastructure component construction, from the design phase, **the approval decision** is taken during a Conference of Services.

The key findings for NRAs in Group 2 are given below.

- **France:** the government has devised a decentralised process, which gives full responsibility to the DIRs to decide on M&O activities within a given budget. The relationship between DIT (Direction des infrastructures de transport) and DIRs (Direction des infrastructures régionale) is governed by a contract (Contrat de Gestion).
- **Italy:** when it comes to new infrastructure components construction, a key role is played by the **Conference of Services**, a governmental institution composed of central/regional government members, local authorities members, and road network administrators.
- **Spain:** environmental associations can influence the definition of new construction projects; private associations (e.g. motorbikes associations) can also influence the definition of road maintenance plans.

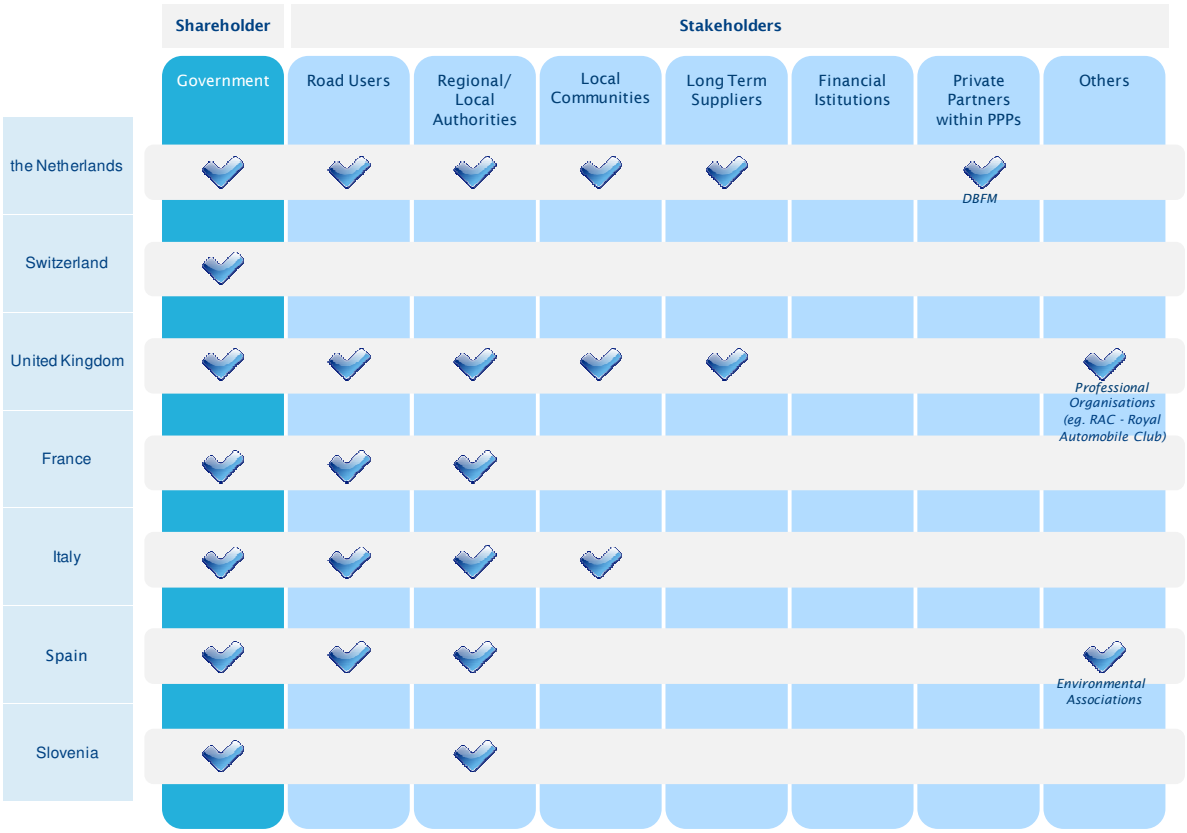
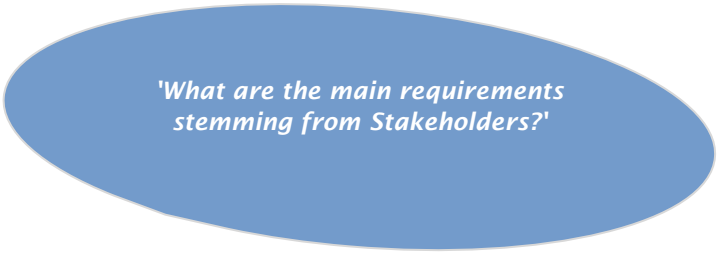


Figure 14: Overview of main shareholder/stakeholders in LCC/AM issues within NRAs

2.5.2 The requirements of NRA shareholders and stakeholders



NRAs gather stakeholder requirements and expectations in different ways.

Managing and meeting stakeholder expectations is key to the successful management of a road network. Based on questionnaire responses, the **main requirements** identified by the shareholder/stakeholders of the NRAs consulted can be summed up as follows:

- to improve road safety;
- to guarantee the availability of road itineraries (e.g. measured as travel time during maintenance, percentage of traffic jams, etc.);
- to guarantee that legal requirements are met;
- to guarantee that attention is paid to environmental issues (e.g. noise reduction);
- to invest money from the budget in accordance with maintenance needs;
- to foster economic growth through maintenance activities;
- to reduce the cost for public transport during maintenance;
- to focus and to prioritise maintenance expenditures on specific road sections.

2.5.3 Channels and means of communication between NRAs and stakeholders

The channels and means of communication adopted by NRAs depend on the kind of stakeholder they are dealing with.

As illustrated in the figure below, NRAs use more formal communication channels *(e.g. meetings, formal reports, etc.)* when dealing with their shareholder, i.e. the ministry/government. Informal channels *(e.g. TV, Twitter, and other infomobility services)* are typically adopted when dealing with road users.

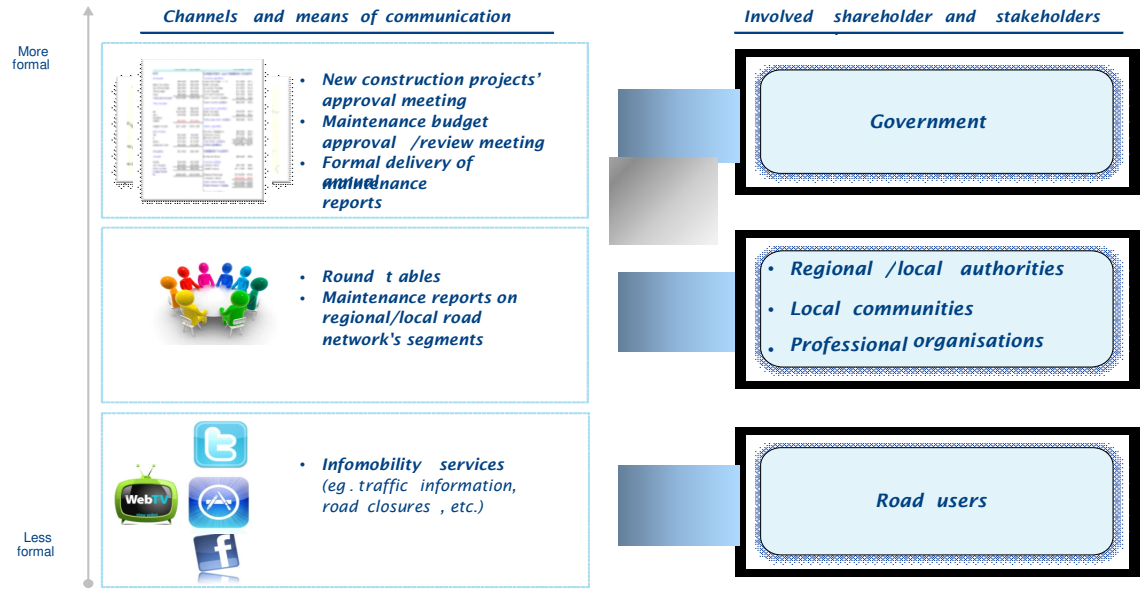


Figure 15: The channels and means of communication used for shareholders and stakeholders

2.6 Supporting tools

The objective in analysing **supporting tools** was to understand how much NRAs are supported by their information systems in the management of AM/LCC data and related processes.

In order to deploy and maintain a comprehensive AM/LCC approach within the organisation, NRA managers need to have an integrated view of technical, financial, and accounting data for their decision-making processes.

For this reason, the questions sent to NRAs sought to analyse and evaluate the maturity level of NRAs tools for each information area (each of which was considered separately) and then to verify the actual presence of an integrated tool, such as a business intelligence system, within NRAs.

Starting with key information areas, the investigation included the following items:

- **technical tools**: supporting tools used mainly by M&O departments to perform LoS monitoring, remote monitoring of plant and equipment, and simulations of different maintenance scenarios;
- **financial and accounting tools:** supporting tools used mainly by CFOs to perform asset valuation analysis, financial simulations, etc;
- **integrated dashboards:** management dashboards, providing an executive and integrated view of road infrastructure key data and KPIs.

Results from interviews and questionnaires show that:

- **technology solutions**, adopted by NRAs to manage road infrastructure, range from **enterprise solutions** (e.g. SAP or Oracle modules) to **customised IT systems** developed within the organisation;
- **maintenance systems are generally integrated into financial systems** in order to disseminate consistent information within the organisation or to stakeholders;
- **a more detailed and systematic tracking model for maintenance expenditures over the network** has been identified by NRAs as an **area for improvement.**

2.6.1 Management dashboards: monitored KPIs

'Management dashboards to support decision making processes: which are the monitored KPI's? Who are the dashboards' users?'

Management dashboards and the identification and definition of KPIs are used to support the NRAs' decision-making processes.

They are frequently adopted as a support for several different management areas, such as infrastructure management *(*e.g. KPIs reporting on the physical status of objects of the infrastructure*)*, monitoring of the operational aspects of maintenance (*e.g. monitoring milestones)*, monitoring the financial aspects of maintenance *(e.g. current expenditures vs. yearly budget).*

The following table highlights the main findings of the questionnaire analysis:

	Country	*Monitored KPIs/Analyses performed using dashboards*	*Dashboard users*
NRAs Group 1	***the Netherlands***	• RWS supports its decision-making processes using dashboards that present indicators and performance indicators related to the **availability, reliability, and safety** of road network. • **Performance indicators** are directly related to the activities of RWS, while **indicators** are related to policy goals (outcome) of the Ministry of Infrastructure and Environment.	• Ministry of Infrastructure and Environment • RWS
	Switzerland	• No specific dashboard was mentioned in the questionnaire	N/A

	Country	Monitored KPIs/Analyses performed using dashboards	Dashboard users
	United Kingdom - England	• HA monitors and evaluates its assets' condition to support strategic decision-making. The network's assets are divided in the following categories: Pavement, Structure, Geotechnical, Drainage, Technology, Lighting. For each category, HA uses a specific methodology to provide a summary evaluation of the assets' current condition.	• Network Delivery and Development Department
NRAs Group 2	***France***	• Performances are measured by IQRN and IQOA indicators, which provide information on the real condition of the infrastructure in terms of deterioration rate at macro level (on the whole network).	N/A
	Italy	• Anas uses a dashboard to monitor and control the progress of **preventive maintenance works** in terms of the completion of milestones (from the project's approval to the conclusion of works). • For **pavement maintenance**, KPIs relating to pavement condition are measured through surveys executed by automatic tools provided by Research and New Technologies Department. • For **routine maintenance**, there is **real-time monitoring of related expenses**. The dashboard allows both the actual quote of committed budget and the actual expenditures provided to external contractors to be monitored.	• M&O Department • CFO
	Spain	• **Annual budget compliance** and **cost deviations** are monitored and analysed. • From the **infrastructure's inspection results**, the status of infrastructure components is traced into systems in order to know the effectiveness of performed measures.	• General Manager • Deputy Manager

	Country	Monitored KPIs/Analyses performed using dashboards	Dashboard users
	Slovenia	• Performances are measured using several indicators such as longitudinal evenness, skid resistance, texture depth, etc. These measurements are provided by periodic assessments of road pavements and bridges conducted by the NRA.	• NRA's management involved in the preventive maintenance planning processes

Figure 16 and

Figure 17 show some KPIs developed by NRAs.

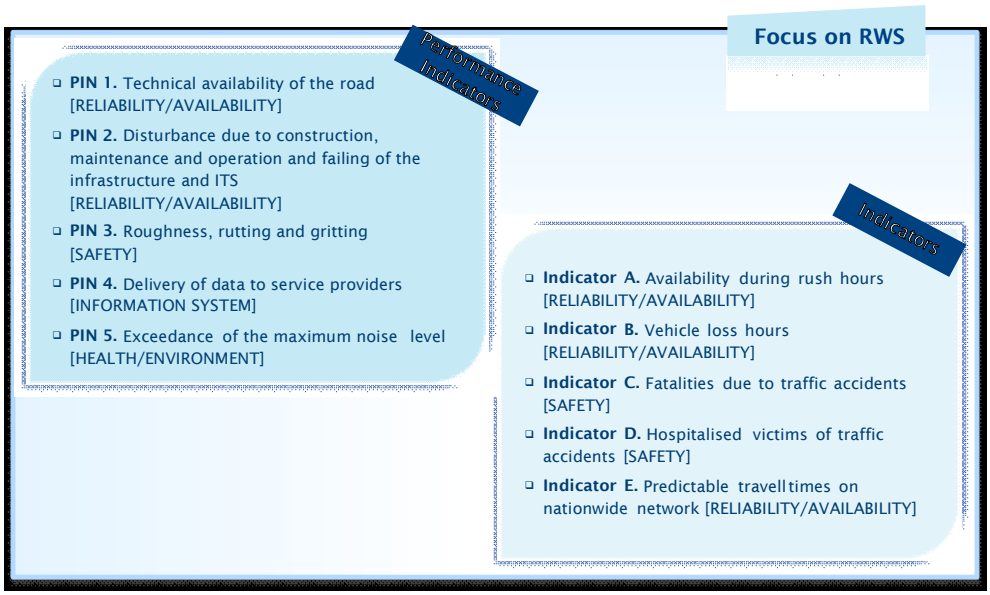


Figure 16: Examples of KPIs monitored by RWS

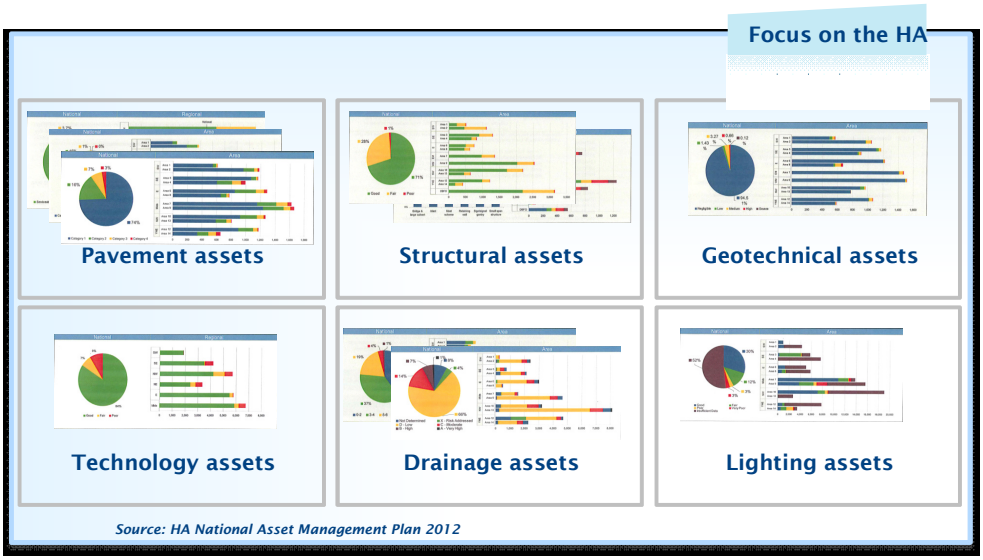
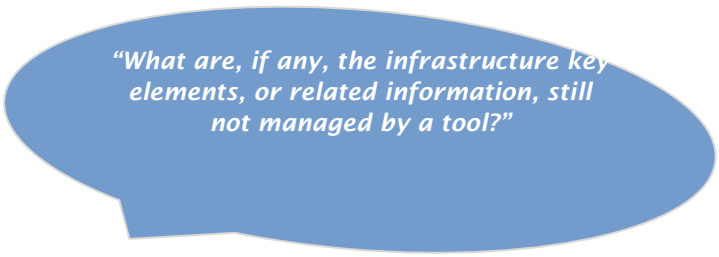


Figure 17: Examples of KPIs monitored by the Highways Agency

2.6.2 Information needs



NRAs are seeking improvements in their knowledge bases. In particular, a more detailed level of information on road infrastructure (e.g. maintenance expenditures assigned to asset objects/components) would allow NRAs to develop a more solid know-how on their road network.

In addition to their specific needs, almost all NRAs have **highlighted requirements for improving IT tool functionalities** in order to perform better breakdown analyses of maintenance expenditures.

The main requirements for each participating NRA are identified in the following table:

	Country	Main information requirements
NRAs Group 1	*the Netherlands*	• Connect **new construction planning & maintenance planning** (connections for maintenance planning and SAP, and connections for new construction planning and SAP have already been done); • Possible information needs may involve **maintenance expenditures** with a **breakdown** into single components (e.g. for cases with more works in a single contract);
	Switzerland	• **Electromechanical elements** are not managed by a tool yet.
	United Kingdom - England	• **Improve the quality of information** of asset databases through IAM IS (Integrated Asset Management Information System); • Development of appropriate tools to **derive draft maintenance schemes and programmes of work,** based on improved asset condition and deterioration held in IAM IS.
NRAs Group 2	*France*	• Possible extension to knowledge relating to maintenance expenditures of an **individual infrastructure components**. • A few issues connected to the database updating process.
	Italy	• Lack of knowledge relating to maintenance expenditures on **individual infrastructure components.** • Anas is working to extend the number of some infrastructure components (e.g. tunnels and related plant) that are remotely controlled.
	Spain	• Improvement of the **integration of accounting systems and technical systems**. • Lack of knowledge relating to **maintenance expenditures** on **individual infrastructure components**.
	Slovenia	• Regarding this matter, no key findings have emerged.

2.7 Development path

The objective in analysing **development paths** was to understand which steps Group 1 NRAs—which already have an LCC-oriented road maintenance strategy in place—have taken and what main elements and critical factors are deemed relevant.

As far as the **NRAs in Group 2** are concerned (these NRAs have not yet developed such an approach or are only starting to develop one), this objective was to identify steps envisaged by them.

Results from interviews and questionnaires show that:

- **no NRA in Group 1 feels that it has completed its development path towards an LCC/AM model**;
- **almost all NRAs** have identified the improvement of their **asset management systems as a key stream** to be activated within the organisation;
- **full commitment of the organisation** and **integration between key areas** are the **key success factors** identified by NRAs.

2.7.1 Development path: the main elements

'Concerning the implementation of an LCC approach and/or AM architecture, when did the process start? Did it start with a comprehensive strategy or by preliminary steps?'

Focusing in particular on the NRAs in Group 1 and their implemented LCC/AM approaches, this section investigates **the main elements associated with the implementation** of such an approach.

Almost all NRAs recognise that both areas involving technical and financial data complement each other and must be better interlinked.

Moreover, most of them identify routine maintenance and preventive maintenance; only the Netherlands has been developing an LCC/AM strategy for new constructions.

	NRAs Group 1			NRAs Group 2			
	the Netherlands	Switzerland	United Kingdom	France	Italy	Spain	Slovenia
Starting date	3-5 years ago	Over 10 years ago	3-5 years ago		1-2 years ago		3-5 years ago
Adopted Strategy	*Comprehensive strategy*	*Comprehensive strategy*	*By preliminary steps*		*By preliminary steps*		• *By preliminary steps* • *By macro areas*
Areas involved	• Technical Data • Financial Data	• Technical Data • Financial Data	Technical Data	*Direction des Infrastructures de Transport hasn't designed any specific project streams focused on AM /LCC development yet.*	• Technical Data • Financial Data	*Direccion General de Carreteras hasn't designed any specific project streams focused on AM /LCC development yet.*	Technical Data
Impacted Maintenance activities	✓ Routine Maintenance ✓ Preventive Maintenance ✓ New Construction	✓ Preventive Maintenance	✓ Routine Maintenance ✓ Preventive Maintenance		✓ Routine Maintenance ✓ Preventive Maintenance		✓ Preventive Maintenance
Impacted items *(Pavement, Tunnels, Bridges, etc.)*	All items	All items	All items		All items		Pavement
Progress Status	***On Course Advanced***	***On Course Advanced***	***On Course Advanced***	***On Course Preliminary***	***On Course Preliminary***	***On Course Preliminary***	***On Course Preliminary***

Figure 18: *Overview of main elements of LCC/AM deployment*

2.7.2 Planned/activated streams

"How many streams of LCC/AM have been planned and which are the key elements of each planned stream?"

The objective of this section is to identify **planned/activated streams** relating to an LCC/AM strategy within NRAs.

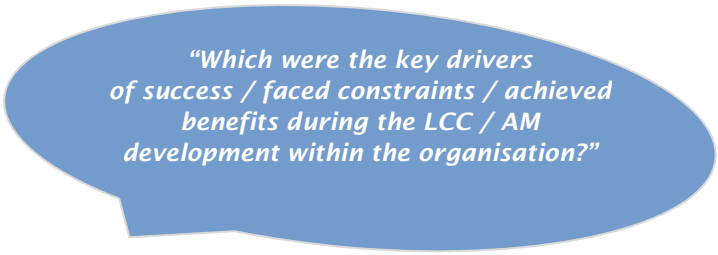
Responses reveal that almost all NRAs have activated or are going to activate project streams relating to asset management systems *(e.g. improvement of asset management systems/tools/database in the case of RWS; improvement of knowledge of infrastructure deterioration levels in the case of ANAS)*. Only a few NRAs are focusing their activities on improving accounting systems.

Figure *19* illustrates an overview of the planned/activated project streams outlined in responses to the questionnaire.

Main Project Streams activated and ongoing	the Netherlands	Switzerland	United Kingdom	Italy	Slovenia
Improvement of **asset management systems** in order to have complete and homogenous information of **infrastructure components.**	✓ ***BMS/BIM*** *(improvement on asset management systems /tools/databases)*	✓ ***Global AM*** *(integrated database for all components and asset management for each item)*	✓ ***Asset Data & NAMP*** *(National Asset Management Plan)*	✓ **Asset Knowledge Improvement** *(improvement of knowledge of infrastructure deterioration levels)*	✓ ***Pavement Management System*** *(on going project, full implementation for whole road network in 3 years)* ***Bridge Management System*** *(to be planned)*
Initiatives to define and measure new KPIs and SLA focused on risks and LCC.	✓				
Improvement of **accounting systems** in order to account maintenance expenses directly to infrastructure components.				✓ *New Routine Maintenance Accounting System*	
Deployment of **AM principles** within procurement processes	✓ *AM in DBFM (Design, Build, Finance, Maintain) contracts*				

Figure 19: *Overview of main project streams, activated and on-going*

2.7.3 Constraints, key drivers of success and benefits



This objective of this section is to understand the possible success factors, obstacles, and expected benefits of an LCC/AM development path (on-going or planned) that have been identified by each NRA. The ultimate goal is to find out whether it would be possible to highlight a common vision among selected NRAs in order to disseminate it to other road authorities. According to the feedback received, the following conclusions can be drawn:

- **Major constraints** were faced due to **inconsistent data**, **lack of asset knowledge,** and **functional resistance.**
- **Key drivers of success** are mainly considered to be a combination of the **full commitment of the organisation**, a **step-by-step process,** and **integration between areas**.
- **Achieved benefits** include **improved interfaces with shareholders/stakeholders**, **improved effectiveness** both in strategy processes and execution processes, supported by better knowledge of road infrastructure, and an increase of road user satisfaction**.**

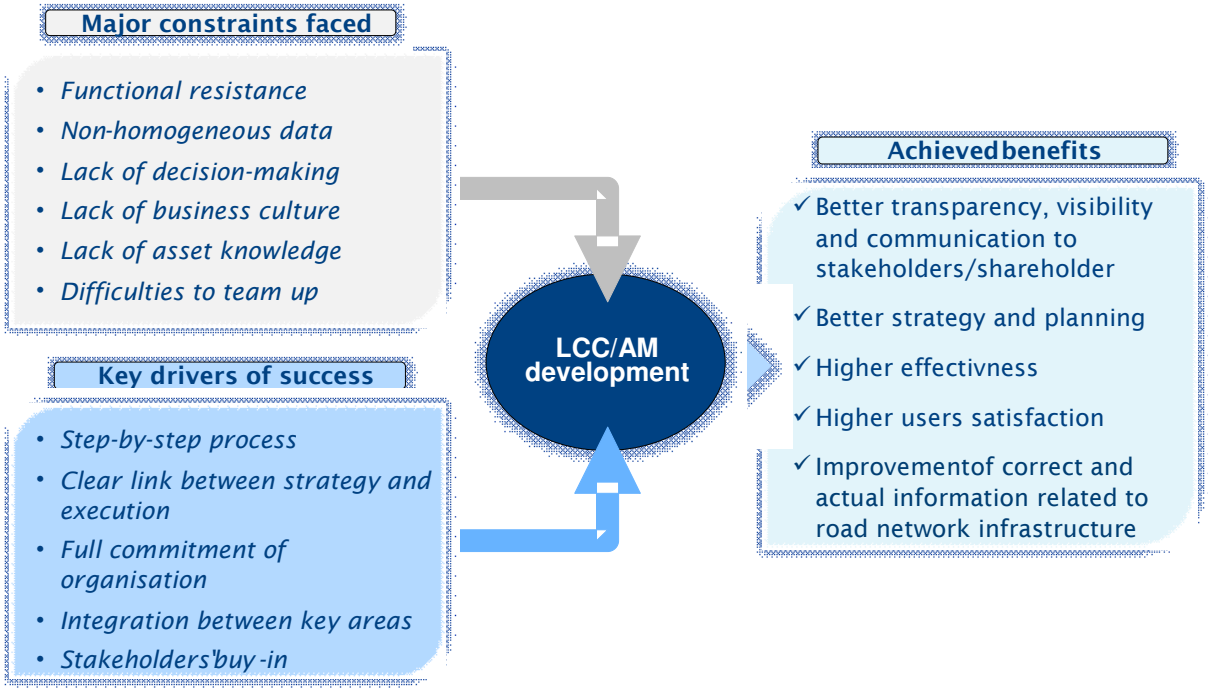


Figure 20: *Overview of constraints, key drivers of success, and benefits of LCC/AM development*

3 GUIDELINES AIMED AT ADOPTING AN AM/LCC APPROACH IN NRAs

3.1 Common definitions

3.1.1 Asset management

In recent years, road administrations have increasingly been trying to balance growing transportation demand, ageing infrastructures, and constrained resources. Any technical methodology capable of providing efficient resource allocation and balancing criteria and guidelines is considered to be particularly relevant.

To this end, asset management offers a systemic process of maintaining, upgrading, and operating physical assets cost-effectively using a series of road management procedures and tools. It combines engineering principles with sound business practices and economic theory. Most importantly, asset management provides decision-makers with a framework for both short and long-term planning. Key elements of a typical asset management system are:

Some general definitions of asset management as applied to road sector drawn up by **some of the most relevant institutions in the AM field** are given below.

AIPCR/PIARC defines asset management as:

> *'A systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organised and flexible approach in order to achieve road users expectations.'*

PAS 55 (converted into a standard by ISO 55000) defines asset management as:

> *'Systematic and co-ordinated activities and practices by which an organisation optimally manages its physical assets and their associated performance, risks and expenditures over their lifecycles for the purpose of achieving its organisational strategic plan.'*

The **Organisation for Economic Co-operation and Development (OECD)** states that:

> *'Asset management is a systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organised and flexible approach to making the decisions necessary to achieve the public's expectations.'*

The **New York State Department of Transportation (NYSDOT)** defines AM as:

> *'Asset management is about managing administration resources more like a business. [..] This business-like approach of asset management requires estimation of the value of infrastructure assets, as this value is a significant factor in determining priorities for future investment'*

As such, asset management is key to achieving several benefits:

Asset management is based on a set of processes and tools relating to network management and relationships with shareholders and stakeholders that enable NRAs to:

- ✓ **optimise the 'total cost of ownership' relating to management of road infrastructures;**
- ✓ **secure funding for routine and preventive maintenance, through a multi-year investment plan based on a set of levels of service;**
- ✓ **prioritise preventive maintenance and maintenance operations based on the current state of roads, risk analyses, life cycle costs, and projected Levels of Service (LoS).**

3.1.2 Life cycle cost analysis

Life cycle cost analysis (LCCA) is an evaluation technique that is applied when considering certain **transportation investment decisions**.

LCCA is applied when a road authority has to undertake a project and is seeking to determine **the lowest life cycle cost,** i.e. the most cost-effective **means to accomplish the project's objectives**. LCCA enables the analyst to make sure that the selection of a design alternative is not based solely on the lowest initial costs, but also considers all the future costs (appropriately discounted) over the project's usable life.

The **LCCA approach** enables **the total cost comparison** of competing design (or preservation) alternatives, each of which is appropriate for implementation of **a transportation project—**an investment that fulfils the requirements to provide a given level of performance to the road users).

All relevant costs that occur throughout the life of a possible alternative, not simply the initial expenditures, are included.

Roads authority costs	User costs associated with work areas
• Design andengineering • Land acquisition • Construction • Reconstruction/rehabilitation • Preventive/routine maintenance	• Delays • Crashes • Vehicle operating costs

Illustrative

Figure 21: Examples of costs considered in LCCA

3.2 Common core system

Thanks to lessons learned from previous reports, the results of the survey, and the interviews conducted, **a common core system for asset management/life cycle costs management for NRAs** has been devised.

The evaluation of AM/LCC comprises several intertwined steps, both on the technical side and on the economic side (management control, accounting, financial). The objective of these steps is to develop a full-range LCC model that shall be integrated into the AM framework and that shall be provided for specific road stretches with increasing levels of detailing, from asset types to asset objects and asset elements.

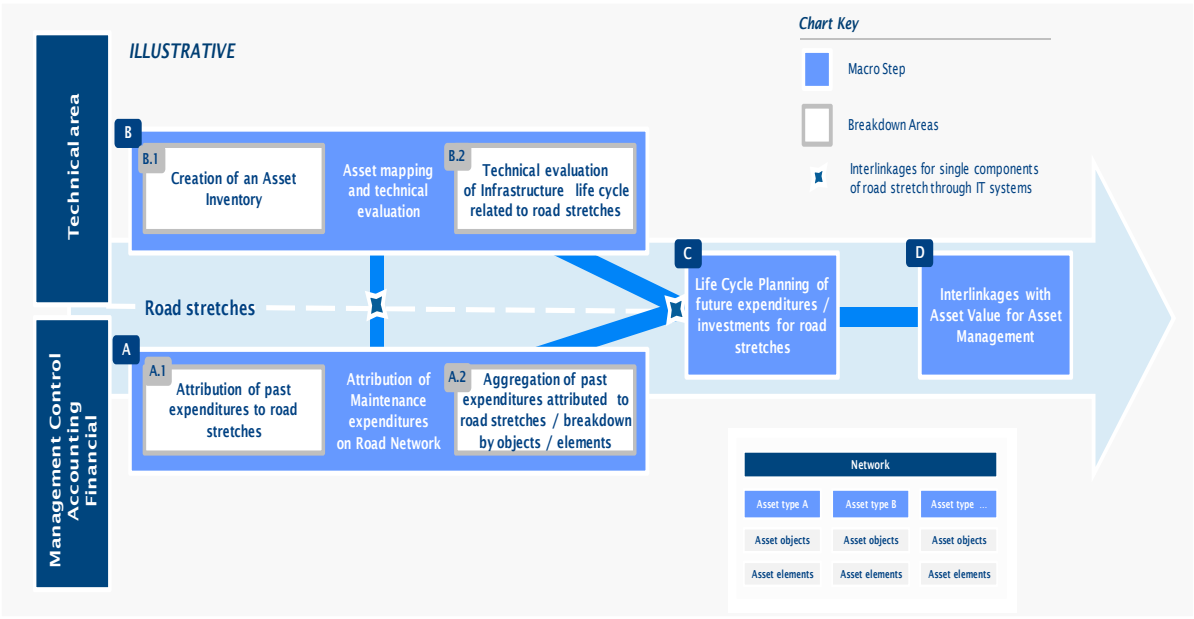


Figure 22: LCC/AM core system

The following paragraphs provide details of each section of the proposed framework.

3.2.1 Attribution of maintenance expenditures on the road network

The attribution of maintenance expenditures on the road network is the first step identified in the framework and it includes:

- **attribution of past expenditures to road stretches** (A.1 action): **maintenance expenditures are directly attributed to single road stretches** within the NRAs' overall network; no further breakdown is performed (incurred costs should be split into sub categories such as construction costs, routine maintenance costs, safety improvement costs, etc.);
- **aggregation of past expenditure attributed to road stretches and breakdown by objects/elements** (A.2 action): the objective of this action is to get a more detailed knowledge of maintenance expenditures over the NRA's network by:

- **further breaking down maintenance expenditures** within **road stretches for specific road components/elements/works**;
- **aggregating all past data** concerning those road stretches in order to provide a complete picture of overall historical interventions on road stretches;

- common database and IT system/tools that act as enablers for this action.

Common coding/classification is needed for each object/component of the asset.

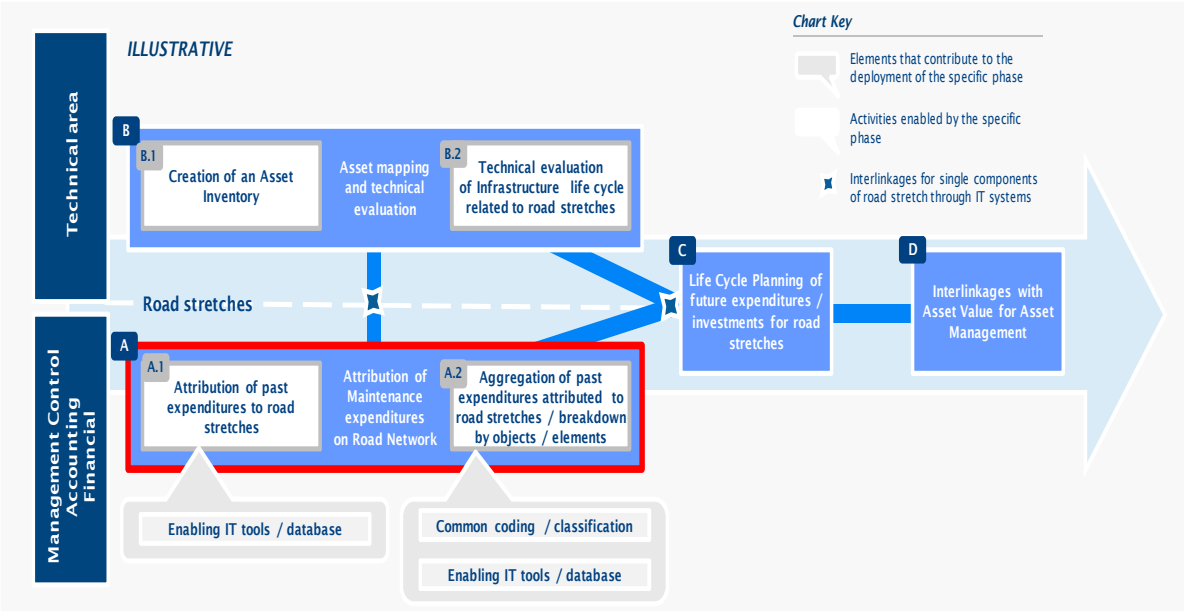


Figure 23: Step A: Attribution of maintenance expenditures on the road network

3.2.2 Asset mapping and technical evaluation

Creating and maintaining an asset inventory and technical evaluation of infrastructure relating to road stretches involves two different actions:

- **The creation of an asset inventory** (B.1 action), which includes:
  - **asset mapping**: identification of all relevant assets for road stretches (objects, components), with related information starting from asset's design initial data; assessment of the **state of the roads** based on visual and automated means;
  - **a past interventions history**: quantification of all interventions relating to road stretches.
- **The technical evaluation of the infrastructure's life cycle** (B.2) relating to road stretches, which includes:
  - **provided LoS** monitoring;
  - **defined safety needs** (e.g. stemming from the knowledge of accident rates on selected roads);
  - **risk evaluation**, also based on what-if analysis with probabilistic valuations;
  - the definition of the technical life span, for each component/work category.

Interconnections with an economic database of past expenditures by **object/component** through IT systems and frequency of database update are key.

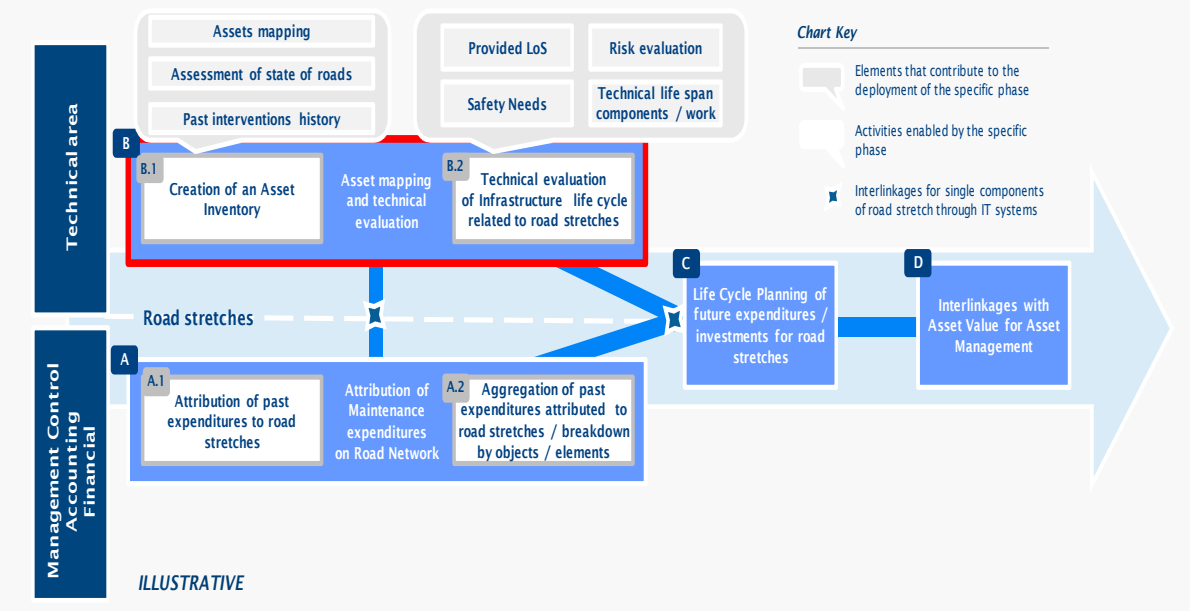


Figure 24: Step B: Asset mapping and technical evaluation

3.2.3 Life cycle planning of future expenditures on/investments in road stretches

Life cycle planning of future expenditures on/investments in road stretches is a key step of the proposed framework as it connects the technical side with the accounting and financial sides. It includes:

The planning of future expenditures on road stretches on the basis of past expenditures and projections stemming from infrastructure life cycle represents the key link between the technical and economic area:

- taking into account the **expected levels of service** as defined in the shareholder agreements in order to use them as guidelines for the prioritisation of investments;
- implicating a **quantification of the LCC expenditures** relating to the technical life cycle of components/elements within road stretches;
- **providing links with finance for defining the timing of cash needs** (also in relation to potential imbalances within the forecasted period).

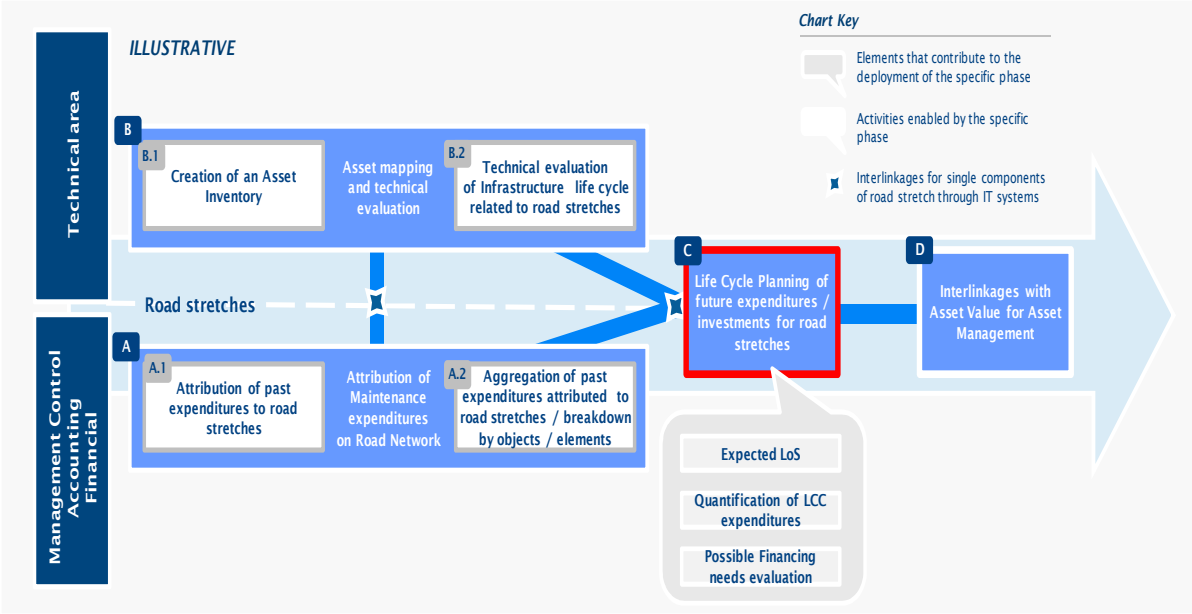


Figure 25: Step C: LCC planning of future expenditures on/investments in road stretches

3.2.4 Interlinkages with asset value for asset management

The last step in the framework, interlinkages with asset value for asset management, includes:

- **accounting interlinkages** with the overall asset value (preferably through historical cost of investments relating to single road stretches), which enable the identification of potential increases/decreases in the overall asset value as a result of NRA's policies;
- the **calculation of investment ratios** based on the overall asset value, possibly relating to LoS, that can **provide a framework** for each specific asset and enable comparisons between different NRAs **over the years**;
- **on-going negotiations with the shareholder** that might be improved by providing a detailed assessment of the status of asset value.

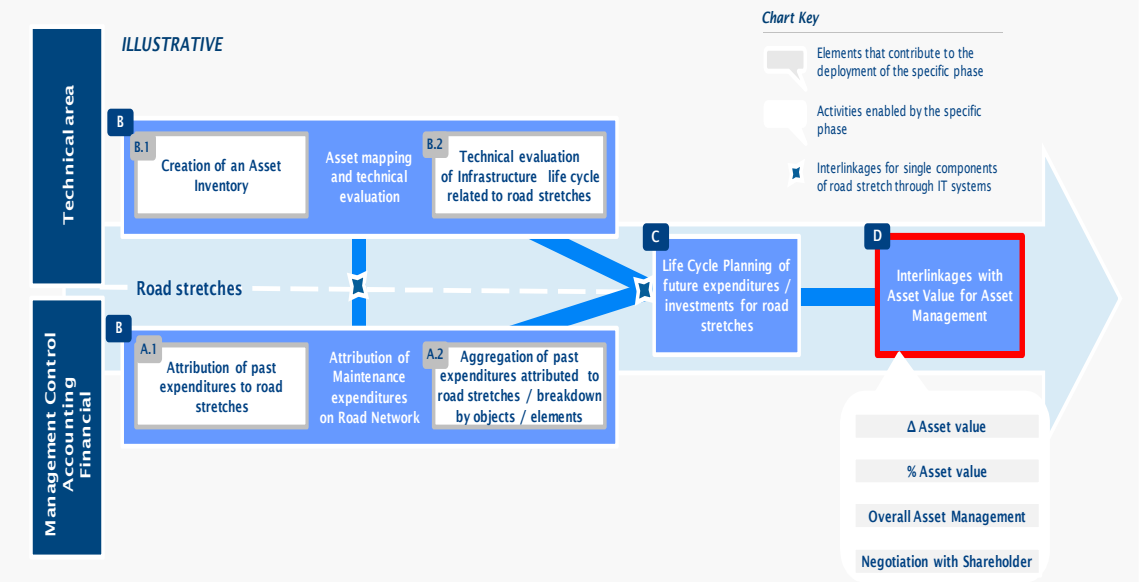


Figure 26: Step D: Interlinkages with asset value for asset management

3.2.5 LCC/AM core systems and panel NRAs

A breakdown analysis allows the areas of the LCC/AM core system covered by each NRA and the key findings concerning each model to be highlighted. As shown in the figure below, **no NRA on the panel covers all LCC/AM core system steps yet.**

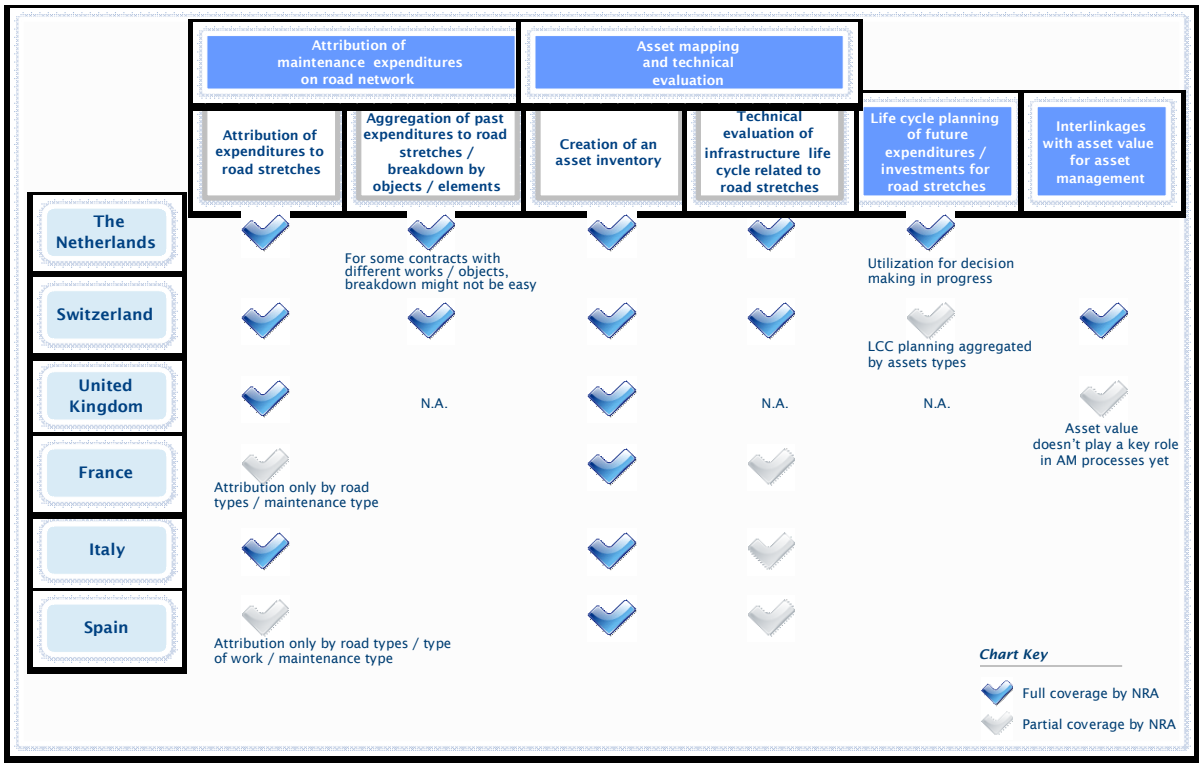


Figure 27: LCC/AM core system: overview of NRAs

In particular, while there is some **general attribution of past expenditures to road stretches** (Group 1 and one case in Group 2), **other steps are not uniformly distributed**.

Interlinkages with overall asset value are considered only for **Switzerland** and the **UK** (although **asset value** is also calculated for **France**, **Italy,** and **Spain** at different levels and for several purposes).

3.3 Specific elements relating to accounting principles

An LCC approach requires that **NRAs manage the whole road network through an integrated view** of all the data *(technical, accounting, and financial)*.

This investigation has highlighted a number of **noteworthy elements** relating to **accounting principles** that are key points **for an LCC approach:**

- to **attribute maintenance expenditures to single infrastructure objects** and related components in order to enable breakdown of expenditures analysis;

Breakdown of past expenditures to single object — Illustrative

		Year 2009			Year 2010			Year 2011		
		Maintenance's expenditures attribution			Maintenance's expenditures attribution			Maintenance's expenditures attribution		
Asset type	Asset object	Routine Mainten.	Prev. Mainten.	Network Improv.	Routine Mainten.	Prev. Mainten.	Network Improv.	Routine Mainten.	Prev. Mainten.	Network Improv.
Bridge	Bridge 1	€ 200.000	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ 4.000.000
Bridge	Bridge 2	€ 20.000	€ -	€ -	€ 300.000	€ -	€ -	€ -	€ 500.000	€ -
Bridge	Bridge 3	€ -	€ 100.000	€ -	€ -	€ -	€ -	€ 300.000	€ 100.000	€ -
Bridge	Bridge n	€ -	€ 3.000.000	€ -	€ 200.000	€ -	€ -	€ -	€ 3.000.000	€ -
	...	€ -	€ -	€ -		€ -	€ -	€ -		€ -
Roadway	Pavement 1	€ 180.000	€ -	€ -	€ -	€ -	€ -	€ 200.000	€ -	€ -
	...	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Tunnel	Tunnel 1	€ -	€ 1.000.000	€ -	€ 150.000	€ -	€ -	€ -	€ 1.000.000	€ -
Tunnel	Tunnel 2	€ 100.000	€ -	€ -	€ 150.000	€ 1.000.000	€ -	€ 150.000	€ -	€ -
Tunnel	Tunnel 3	€ -	€ 1.000.000	€ -	€ -	€ -	€ -	€ 150.000	€ 1.000.000	€ -
Tunnel	Tunnel n	€ 200.000	€ -	€ 10.000.000	€ -	€ -	€ -	€ -	€ -	€ -
	...	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Drainage		€ 100.000	€ -	€ -	€ -	€ -	€ -	€ -	€ 1.000.000	€ -
...		€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
	Total	€ 800.000	€ 5.100.000	€ 10.000.000	€ 800.000	€ 1.000.000	€ -	€ 800.000	€ 5.600.000	€ 4.000.000

Figure 28: Example of the attribution of expenditures to single objects

- to **aggregate past maintenance expenditures** in order to get a full picture of when/where/what the NRA has spent to maintain/improve its infrastructure;
- to **perform asset valuation,** considering not only the investments made, but the depreciation as well, combining **asset type life cycle** with **actual status of asset objects**;

Road Stretch Valuation — Illustrative

Year 2009					Year 2010				Year 2011			
Road Stretch Historical Cost	Road Stretch Initial Value	Capitalised Expenditures	Depreciation	Road Stretch Final Value	Road Stretch Initial Value	Capitalised Expenditures	Depreciation	Road Stretch Final Value	Road Stretch Initial Value	Capitalised Expenditures	Depreciation	Road Stretch Final Value
€ 50.000.000	€ 250.000.000	€ 15.100.000	€ 500.000	€ 264.600.000	€ 264.600.000	€ 1.000.000	€ 600.000	€ 265.000.000	€ 265.000.000	€ 10.500.000	€ 1.000.000	€ 274.600.000

Figure 29: Example of an annual road stretch valuation

- to identify **performance indicators** to link **asset value** with the **provided LoS**;
- to also consider **user costs** (e.g. travel time, vehicle costs) as a consequence of NRAs' more prominent role as a mobility provider.

3.4 Recommendations and workable guide for LCC in NRAs

The combination of the proposed LCC/AM core system and findings emerging from the analysis of NRAs makes it possible to identify **a set of recommendations and a workable guide** for LCC within NRAs.

On the basis of the proposed core system, an **overall path to implement an asset management approach that is inclusive of LCC shall be agreed for NRAs** as a whole. In doing so, **some available best practices or illustrative experiences** (see Chapter 3 of the present document) **shall be considered** for specific areas, in particular those relating to the more advanced countries in CEDR TG3 Group 1.

In more detail, **it is recommended that the overall value of network assets be taken into consideration** as an aggregation of all road stretches belonging to the network since this value constitutes the major element that bridges the gaps between accounting, finance, and technology.

The proposed methodology for establishing infrastructure values is that of the **historical cost approach**. In those cases where historical cost information is not available, especially over a long period of time, a proxy estimate using the **current replacement cost** shall be used instead, based on the actual conditions of the assets, i.e. '***Brownfield***', rather than '*Greenfield*' one.

The definition of a unifying model shall consider an **average time of implementation** for all major steps, also considering both intertwined steps that might have development areas in common and best practices dissemination.

Pioneering NRAs highlighted the fact that the **development of advanced LCC/AM models** typically involves a time-span in the **range of three to five years**.

It is possible, however, that these times could be reduced for subsequent developments, capitalising on previous experience and using organisational mechanisms (e.g. inter-functional committees, management by objectives mechanisms, etc.) to support this change.

Moreover, the **consideration of the value of network assets**, which is key to AM/LCC systems, **could be done in one year or less** depending upon the availability of information within NRAs and the IT systems in place.

Therefore, in light of the proposed core system, specific recommendations have been made, according to the **differences between the so-called 'Group 1' NRAs**, where LCC has been applied for many years for integrated decision-making and asset management processes (AM) and '**Group 2' NRAs**, where some aspects of LCC are applied, starting from the latter.

These recommendations should be regarded as general; **each NRA should adapt them accordingly to suit the current state** of its organisation, processes, and IT systems.

3.4.1 Group 2 NRAs (or NRAs where some limited features of LCC are applied)

i. Create an **asset inventory** by identifying all relevant assets for road stretches: objects, components, and related standard maintenance costs (*this activity doesn't apply to Group 2 NRAs where an asset inventory has already been implemented, but it can be considered an initial step for other NRAs that are at the start of the AM/LCC development process within the organisation).*

ii. **Assess the state of all road elements/objects in a cyclical way,** based on automated means.

iii. **Identify and monitor levels of service** provided by the road network that have been developed with the shareholder.

iv. **Identify the safety needs of the road network**.

v. **Attribute past maintenance expenditures** to road stretches through a specific IT system.

vi. Over time, **aggregate and provide a breakdown of costs for specific road components and elements** within specific road stretches (particularly within large contracts that include different road works) through a common coding and classification.

vii. Implement **comprehensive accounting processes and IT tools in order to trace and update periodically the current expenditures** by single objects and components of specific road stretches.

viii. Evaluate **technical and operational risks** based, among other things, on a what-if analysis with probabilistic valuations.

ix. **Define the technical life-span** of each component/work category.

x. Improve **integration between technical and accounting IT systems** using a **common database** linking asset inventory and asset expenditures.

xi. **Calculate life cycle cost expenditures relating to the technical life cycle** of components/elements within road stretches;

xii. **Plan future expenditures for road stretches** on the basis of past expenditures and projections stemming from infrastructure life cycle, taking into account the expected levels of service agreed with the shareholder;

xiii. **Apply LCC analysis to new infrastructure already in the design phase** in order to improve the planning of future maintenance expenditures**.**

xiv. Provide detailed information and data to financial departments by **defining the timing of cash needs** (also in relation to potential imbalances within the forecasted period).

xv. Take into consideration and **estimate the overall value of network assets** based on a **combination of historical costs data and gross replacements costs (*brownfield*-based)** if no historical data is available.

xvi. Enhance the **calculation of investment ratios based on overall asset value**, which can over the years provide a framework for each specific asset and enable comparisons between different NRAs.

xvii. **Identify potential increases/decreases in the overall asset value** as a result of NRAs' policies.

xviii. **Enhance budget negotiations with the shareholder** thanks to a detailed assessment of the status of asset's value.

3.4.2 Group 1 NRAs (or NRAs where LCC and AM processes are already in place)

i. Over time, **aggregate and provide a breakdown of costs for specific road components and elements** within specific road stretches (particularly within large contracts that include different road works) through a common coding and classification.

ii. Implement **comprehensive accounting processes and IT tools in order to trace and periodically update current expenditures** by single objects and components of specific road stretches, periodically updated.

iii. Improve **integration between technical and accounting IT systems** using a **common database** linking asset inventory and asset expenditures.

iv. Take into consideration and **estimate the overall value of network assets** based on a **combination of historical costs data and gross replacements costs (*brownfield*-based)** if no historical data is available.

v. Enhance the **calculation of investment ratios based on overall asset value**, which can over the years provide a framework for each specific asset and enable comparisons between different NRAs.

vi. **Identify potential increases/decreases in the overall asset value** as a result of NRAs' policies.

vii. **Enhance budget negotiations with the shareholder** thanks to a detailed assessment of the status of the asset's value.

3.5 Success factors for the implementation of the common core system

In order to develop the common core system devised within each NRA**, six relevant success factors** have been identified and should be properly managed by NRAs:

a. **Sharing of LCC/AM benefits with the shareholder**, particularly concerning safety needs, risk evaluations, projected levels of services, asset value, and related implications within planning processes **in order to increase clearness and transparency of NRAs' decision-making** processes.

b. **Full commitment by NRA top-management** in order to establish a clear link between strategy and execution and avoid possible functional resistances and difficulties in working together on the implementation of an LCC/AM.

c. **Availability of detailed asset information and data**, particularly concerning **inventory** (objects and components), **current state** (measured through automatic tools), **and past interventions history** (by single object and component).

d. **Implementation or development of integrated IT tools** such as ERP systems in order to manage and accurately integrate all technical, financial, and economic data relating to network assets.

e. **Adoption of LCC/AM core system by means of a step-by-step approach**, in order to gather the first operating results (e.g. better planning processes, enhanced budget negotiation with the shareholder using the asset value, etc.) within a short time-frame (less than one year), also capitalising on previous NRA experiences.

f. **Development of specific organisational mechanisms** such as inter-functional committees, project management teams, MBO (management by objectives) mechanisms, change management projects, education and training programmes, etc. **in order to support and facilitate the change within each NRA**.

4 THE WAY FORWARD: AM/LCC IN THE CEDR STRATEGIC PLAN 2013–17

4.1 The 2013–17 CEDR Strategic Plan

One of the pillars of the strategic challenges outlined in the Strategic Plan 2013–17 ('SP3') relates to the contradiction between the shortage of financial resources and the growing needs expressed by stakeholders (CEDR, Strategic Plan 2013–17, chapter 3.4, Future Challenges for the NRAs):

'The European road network has roughly the shape and length needed for the coming decades. What must now be improved is the continuity of the quality of the network, from the number of lanes, to the interchanges, the comfort of users, and the traffic management measures. To keep the existing network up and running, the quality of maintenance is of paramount importance. With less money available in most countries, the maintenance of the existing network must be privileged versus new construction. When and where it is not possible to maintain the whole network at a desired level, the introduction of service level agreements must set clear priorities which are understandable and communicated to the public. Asset management becomes essential as it provides a detailed knowledge of the network and a life cycle approach to infrastructure maintenance.'

As a consequence of this proposed approach, for Network Management, 'work will focus on the sharing of best practice relating to road asset management and operation. This will include the impacts of the EU directive on heavy vehicles, best practice in winter maintenance and development of understanding relating to the state of the art of asset management – for the safe and cost effective management of the road network.'

The challenge set by the Strategic Plan for Network Management is to understand and define what is the most efficient and effective way of managing and operating the strategic road networks of CEDR countries, bearing in mind the limited availability of funding and the increasing age of infrastructure assets.

4.2 Asset Management within the framework of the Strategic Plan 2013–2017

The aim of the new task group in SP3 should be to continue the work started in mid-2011:

- to use the results of the activities completed under SP2 in order to analyse how life cycle costs are defined, how they are reflected in accounting systems, and how they are allocated to the various stretches of the road network (performance based);
- to analyse the data collected in order to recommend a set of common definitions, language, and a common core system based on a risk-based approach and framed in a comprehensive and enlarged 'Best practice guide';
- to identify the steps needed to:
    a) set up an LCC integrated system for CEDR NRAs and
    b) widen the LCC system, creating a comprehensive asset management system;
- to prepare a best practice guide for the implementation of an asset management system for road authorities that is able to provide both theoretical and practical tools to improve the quality and efficiency of road infrastructure through the effective management of assets in accordance with risk analysis, user expectations, and government requirements;

- to follow the process of development and introduction of the ISO 55000 Asset Management System Standard, discuss the option for CEDR members, and, if necessary, steer the process of LCC/AM in the right direction;
- to assess the option of launching a new international study like BEXPRAC, based on performance management, i.e. a study based on an homogeneous comparison between CEDR member countries;
- to liaise with other experts' groups involved in similar tasks within international organisations.

In order to reach the above-mentioned goals, the task group will publish a set of reports for practical use based on the analysis of existing technologies and practices in the participating countries as well as a list of recommendations.

At the end of the activities foreseen in the 2013–17 Strategic Plan, the following output will be made available:

- for all CEDR members: identification of the steps for setting up a comprehensive LCC approach as a starting point to building an Asset Management system (interim report);
- for the CEDR members that have already started to implement an Asset Management (AM) process: a continuous update of opportunities, technologies, examples, scientific contributions will be made available (interim report);
- for the CEDR members that are planning to start such a process: a clear set of guidelines, based on best practice and state of the art, will be made available at the beginning of the SP3 time horizon (EB summer 2013);
- for all CEDR members: some concrete applications of practices and procedures will be made available, through the conducting of road surveys extended to road sections managed by the members that participate in the task group (final report);
- the continuous updating of the process of definition of the ISO procedures associated to asset management, as applied to roads and other items within the asset perimeter of a NRA;
- a clear link with the activities on asset management carried out by international organisations, research groups, and academia.

5 CONCLUSIONS

In the last 10–15 years, NRAs worldwide have come to understand that the implementation of an overall asset management system built on life cycle cost principles and integrated into NRA accounting systems offer NRAs (managers, shareholders, and stakeholders alike) several benefits. These benefits relate mainly to better strategies, informed decision-making processes and procedures, and enhanced communication with shareholders and third parties. The LCC approach is the starting point for any long-term, whole-life, asset-based analysis of the components of the capital assets that represent the core of the activity of a road agency. Thinking in terms of LCC implies a certain number of activities: clear identification of each major asset, in-depth long-term analysis of its physical and operational aspects, and construction of a common system of classification of the main aspects of the asset.

Although LCC is a very important and strategic approach, it is not asset management in the full meaning of the term. AM begins with LCC, i.e. a road administration cannot build an AM system without having created a sound LCC basis. However, it also requires many additional steps and strong links between them. In fact, AM embodies several components, such as the definition of the levels of service, the matching between each of them, and a set of ordinary and periodical maintenance activities, the overall planning—both in economic and financial terms and in operational terms—of the related actions for a large enough time span, the actual calculation of the asset value of each asset component, the sum of which gives the overall value of all the assets on a road network.

Because of the differences between NRAs, each agency has a different understanding of how to approach LCC and AM; furthermore, the levels of development of the components of those systems are not homogenous, the differences being determined by the role of the NRA, its history, the guidelines set by the public shareholder, and the attitude towards the different stakeholders.

The core of the task assigned to the task group was to investigate how LCC and AM principles in a number of NRAs are reflected in these NRAs' accounting systems in terms of life cycle cost definitions, accounting principles, and cost attribution within road infrastructure. For this reason, the terms of reference for the task group focused on similarities and/or differences in the way road assets are classified, analysed, and assessed by different NRAs in order to identify the core problems, to analyse the best practices, and to define a set of recommendations for the implementation of an LCC and a comprehensive AM system.

Seven NRAs were interviewed directly with the support of a comprehensive questionnaire based on asset management standards and lessons learned from previous reports. The seven NRAs were France, Italy, the Netherlands, Slovenia, Spain, Switzerland, and the United Kingdom. Three NRAs ('Group 1') demonstrated a more advanced degree of development of the LCC/AM approach (the Netherlands, Switzerland and the United Kingdom), whereas a further four NRAs ('Group 2') have started to develop this approach (France, Italy, Slovenia and Spain).

The results of the comparison of the above-mentioned NRAs may be summarised as follows:

- As to the way NRAs classify their activities relating to road assets:
  - NRAs do not usually capitalise routine operations and routine maintenance expenditures;
  - preventive maintenance expenditures are capitalised by half of NRAs on the panel, but there are significant differences between the NRAs in terms of applied criteria and

calculation methods, mainly relating to the NRA's 'legal structure' (company, agency, department of ministry, etc.) and country-specific rules and regulations;

- network improvement and development are capitalised by almost all NRAs.

- As to the process of asset evaluation carried on by the NRAs:
  - In terms of goals, assets are evaluated by NRAs for different purposes relating to specific objectives: for NRAs' balance sheets, for the state's balance sheets, for financial reporting, for asset management, and for internal purposes as well.
  - In terms of criteria, two main methodologies are used by NRAs to assess assets value: historical cost and gross replacement cost; most NRAs apply the historical cost methodology, with some differences in terms of 'starting date', while a few of them (notably the UK) adopts the gross replacement cost methodology.
  - In terms of type of costs taken into account, expenditures relating to completed works are monitored by all NRAs while internal resources costs are monitored only by few of them; most NRAs capitalise only completed works, while others also include on-going works starting from the design phase.
  - In terms of depreciation criteria, each NRA uses specific amortisation criteria, shifting from asset type life cycle, to asset type life cycle combined with concession period or to no amortisation, depending on the legal structure of the NRA and the goals and criteria of the assets' evaluation.
- As to the extension of a comprehensive system of classification of NRA assets:
  - The technical side is managed using an asset inventory (constantly updated and made of different sub-inventories, reflecting the level of knowledge and regular inspection of the road components) and a periodical technical evaluation of the state of the road network infrastructure.
  - The economic side is managed by means of a detailed attribution of maintenance expenditures on the road network to road stretches; the level of detail and the scope of the attribution varies from NRA to NRA, although the general goal is to acquire a full picture of the maintenance expenditures sustained as a whole for single road network objects.
  - Compared to different levels of O&M activities and expenses, the identification of the LoS and the risk and safety needs evaluation are well developed in NRAs that already have a comprehensive AM system in place. On the other hand, this part of the system is not yet fully developed for the average NRA.

Based on the different approaches and on the analysis of the literature and the state of the art in this area, an LCC/AM core system has been identified; the system is made up of five sub-systems, each focused on a functional relationship between ways of classifying the asset value or the expenses incurred to improve or maintain it. This core system highlights a diversified outlook that can be summarised as follows:

- In general terms, several approaches to LCC/AM management have been detected, with no single unifying model for all NRAs (no 'one fits all' model); this applies both to Group 1 NRAs (mostly developed LCC/AM system) and to Group 2 NRAs; moreover, no NRA in Group 1 considers its development path towards LCC/AM model completed.

- Almost all NRAs have identified the improvement of their asset management systems as a key stream to be activated within the organisation. Although there is some general attribution of past expenditures to road stretches, other steps such as the introduction of LoS, critical analysis of risk factors, and integrated technical economic and financial planning of operations are not uniformly distributed.
- A comprehensive evaluation of the assets—including accounting interlinkages to LCC/AM in order to evaluate the effects of NRA policies on the value of the assets—is not uniformly conducted by all Group 1 NRAs.

At the end of the activities carried out within the framework of the task group, the following steps are recommended:

- The survey about the degree of development of an LCC/AM approach should be extended to other NRAs, with the possible identification of an additional set of best practices.
- A discussion about the different choices and approaches of NRAs in Group 1 and Group 2 should be organised in order to propose a recommended LCC/AM core system.
- An in-depth analysis of the different tools of an LCC/AM system, including a discussion on the importance of assessing and monitoring the asset value on a regular basis, should be conducted.
- A set of recommendations and a workable guide for implementing the core system within each NRA should be prepared.
- A feasibility analysis of technical and economic aspects of the implementation at different levels of a comprehensive LCC/AM approach should be conducted, including a cost-benefit analysis of the different options open to the NRAs in designing the implementation of the system as well as in identifying different time spans for the setting up of the system.

These issues have been identified as the core of the activities that will be carried out in the framework of Strategic Plan 2013–17 by task group N2 (Network Management working group 'Asset Management').

APPENDIX A: PROJECT ORGANISATION, METHODOLOGY, AND ACTIVITIES

1 PROJECT ORGANISATION

Since 2004, CEDR has adopted 4-year strategic plans that identify a set of activities that are of common interest to its members. Within the framework of the current plan, Strategic Plan 2 (2009–12), Task Group 3 ('TG3'), previously named 'Long-Term Investment', focused its scope on 'Asset Management' in 2011.

Since asset management is a relatively innovative approach, CEDR, within task group 3, decided to begin by analysing the aspects of the life cycle cost rationale for NRAs, through the newly-launched project relating to the *'Investigation on the application of Life Cycle Costs principles and the relation to their accounting systems among some selected National Road Authorities'*.

As part of its goals, **TG3 decided to investigate** the extent to which **AM/LCC schemes and systems are being applied by CEDR members**, i.e. within the national road authorities (NRAs) that are members of CEDR, in order to **understand the implications** for a road agency or administration **of adopting** such an approach.

The methodology adopted by the task group included a structured questionnaire distributed to TG3 members and a series of interviews. Both sought to establish the most common approaches of member countries to allocating resources based on asset management and LCC-oriented strategies.

In accordance with the terms of reference, the selected NRAs can be divided into two groups:

- a **first group of NRAs** (Denmark (later retired), the Netherlands, Switzerland, and United Kingdom), where LCC has been applied for an integrated decision-making process (AM) for many years and is the basis for O&M and investment decisions, and
- a **second group of NRAs** (France, Italy, Slovenia (later retired), and Spain) where some aspects of LCC are applied, but without the implementation of a comprehensive framework.

Group	Country	Related NRA
Group 1	United Kingdom	*Highways Agency*
	The Netherlands	*Rijkswaterstaat*
	Denmark	*Vejdirektoratet*
	Switzerland	*ASTRA*
Group 2	France	*Direction des infrastructures de transport*
	Italy	*Anas*
	Slovenia	*Direkcija Republike Slovenije za ceste*
	Spain	*Direccion General de Carreteras*

Figure 30: Overview of NRAs who were members of TG3

2 METHODOLOGY AND ACTIVITIES

A common methodology for achieving the project's objectives was defined within the task group. It consisted of two interconnected streams of analysis:

- A first stream, ***'Analysis of available AM-related reports and studies',*** sought to identify lessons learned from several previous reports through a common approach and understanding; this stream involved the following steps:
  - **Step 1 (report selection)**: identification of available reports relating to the present project, collection of the reports and preliminary analysis, selection of the main reports to be fully analysed.
  - **Step 2 (analysis of the selected reports)**: study of the selected reports and identification of preliminary findings.
  - **Step 3 (drawing of conclusions)**: identification of main findings and lessons learned.
- A second stream, ***'Investigation on the application of LCC principles',*** sought to draw conclusions from the responses of participating NRAs gathered in interviews and through the questionnaire; this stream involved the following steps:
  - **Step 1 (selection of questions)**: identification of key areas of investigation, definition of core and additional questions for each area of interest, questionnaire validation by TG3 members.
  - **Step 2 (questionnaire distribution and completion)**: conducting of direct interviews with the selected NRAs and collection of the completed questionnaires.
  - **Step 3 (drawing of conclusions)**: reporting of main findings from questionnaire responses, identification of guidelines/best practices for LCC/AM approach, final report delivery and validation by TG3 members.

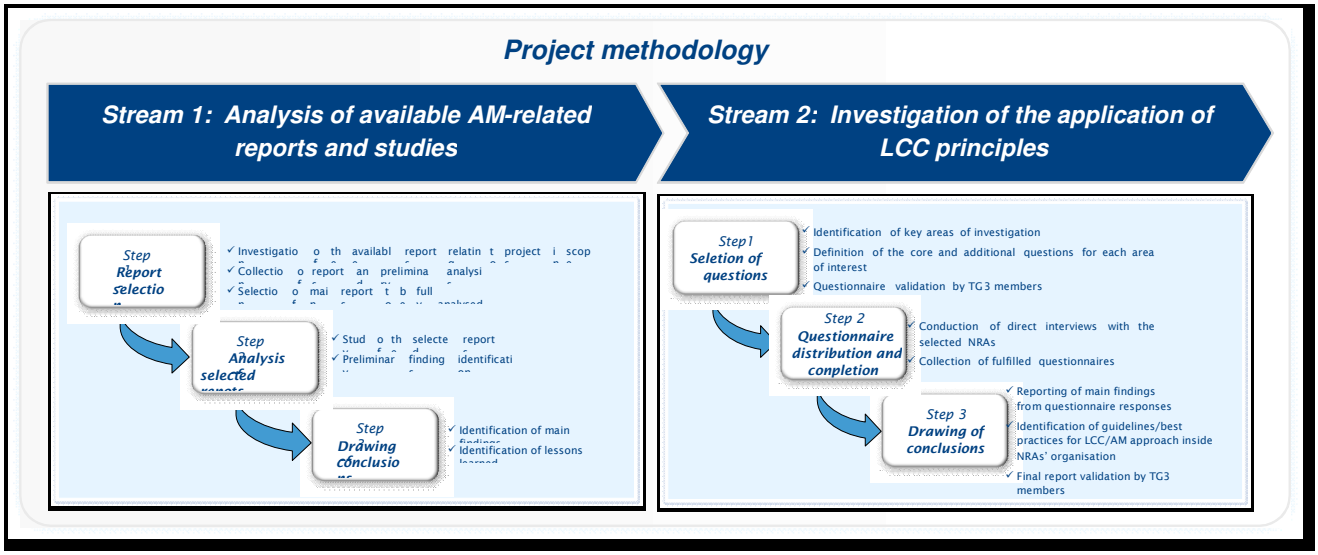


Figure 31: Overview of the TG3 project methodology

In order to gather, assess, and report all the information and data needed, a structured questionnaire was distributed to participating NRAs. In some countries, direct interviews were also performed.

The following table provides an up-to-date overview of the interviews and questionnaire completion.

NRA	Date of interview (2012)	Point of contact (interview/questionnaire)
Rijkswaterstaat (NL)	23 October	*J. Schavemaker*
ANAS (I)	6 November/ 27 November	*M. Adiletta, S. Baietti S. Granati, F. Pasquali*
Direccion General de Carreteras (E)	13 November	*V. Vilanova, G. Arias, M. C. Picon*
Highways Agency (UK)	23 November	*R. Arrowsmith*
Direction des Infrastructures de Transport (F)	3 December	*J. Perol, G. Poirier, S. Gerard*
ASTRA (CH)	4 December	*J.B. Duchoud*

3 QUESTIONNAIRE STRUCTURE AND QUESTIONS

The questionnaire was divided into several areas of investigation; each area containing a **core of mandatory questions** and **a second set of additional questions**. The latter set included questions that were not mandatory; although responses to these questions were appreciated because they provided a broader focus of analysis, the task group was aware that responses to these questions were subject to the respondents' time schedules and the presence of easily available information.

The areas of the questionnaire (for both core and additional questions) are listed below:

- **General LCC/AM outlook**: general elements that define the overall current outlook for the interviewed NRAs.
- These questions were aimed at AM managers (where appointed), or at other representatives within NRAs with an overall knowledge of LCC/AM (depending on each NRA's specific organisational structure).
- **Core LCC/AM pillars**: relevant elements relating to a comprehensive model adopted by the NRA in the following core areas:

- **Technology**: these questions were aimed at O&M managers within NRAs.
- **Accounting**: these questions were aimed at CFOs within NRAs.
- **Finance**: these questions were aimed at CFOs within NRAs.

- **Insight pillars**: relevant elements relating to areas that are important in order to convey a full picture of LCC/AM deployments within the NRAs.
- These questions were aimed at AM managers (where appointed), or at other representatives within NRAs with an overall knowledge of LCC/AM (depending on each NRA's specific organisational structure).

The pillars were:

- development path,
- stakeholders' role, and
- supporting tools.

In addition, a certain amount of quantitative NRA data were requested at the end of both the mandatory and additional sections.

The following figure provides an illustrative view of the section of the analysis.

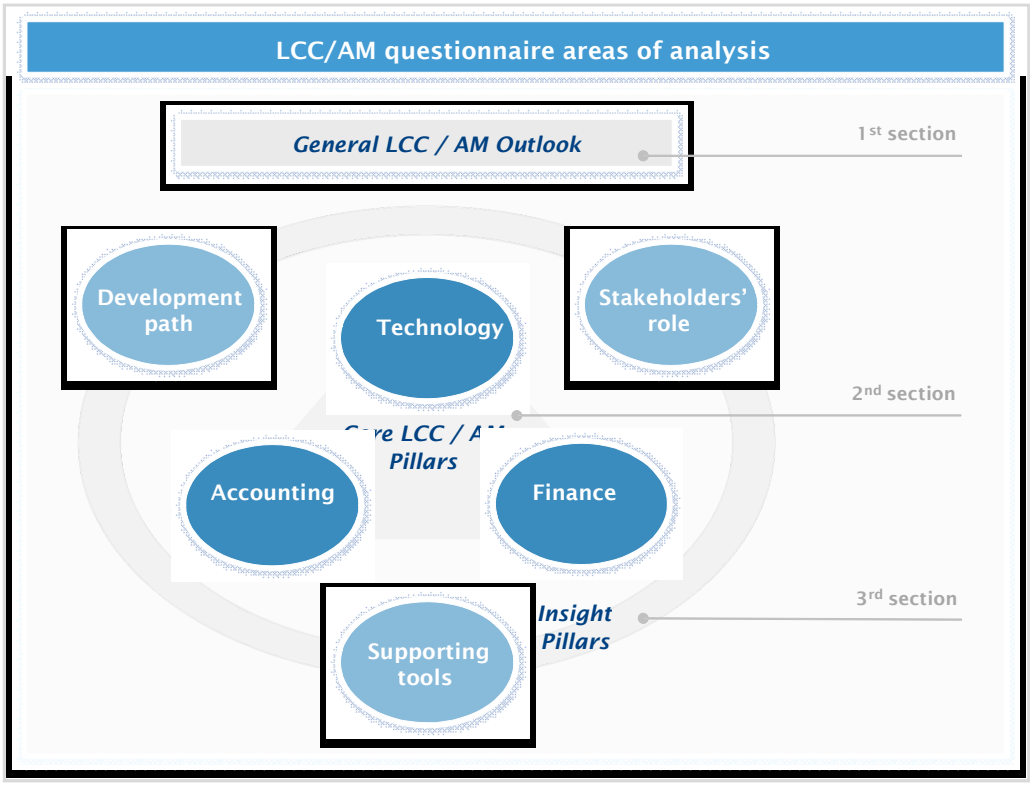


Figure 32: Areas of analysis covered by the questionnaire

The questionnaire, distributed to all participating NRAs, was devised using a modular approach in order to allow the investigation of specific parts of the questionnaire with different NRA respondents.

The questionnaire was divided into seven parts, as described in the following figure, for which main focus areas are outlined.

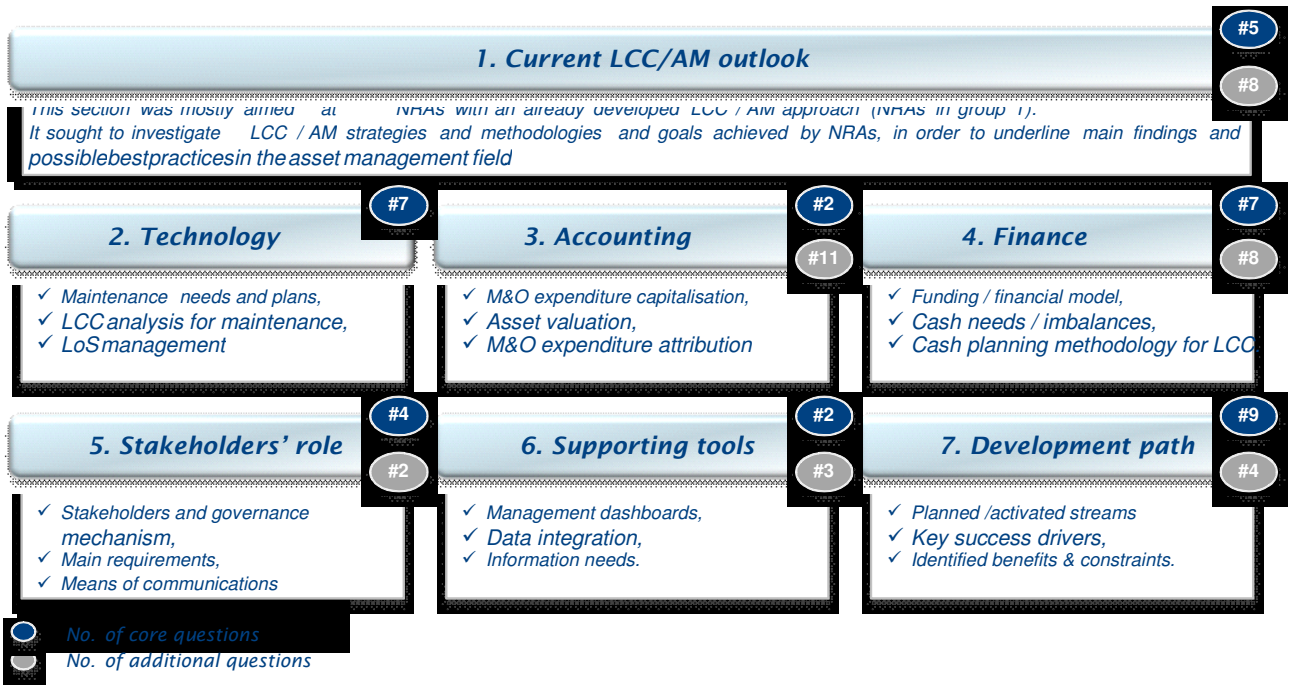


Figure 33: Overview of the questionnaire structure

APPENDIX B: LESSONS LEARNED FROM EXISTING REPORTS

1 INTRODUCTION

- **BEXPRAC** *(Benchmarking of expenditures and practices of maintenance and operation):* the first-ever benchmark project of road maintenance and operation costs undertaken at European level
- **COST** *(European Cooperation in Science and Technology):* intergovernmental framework for European Cooperation in Science and Technology that allows the co-ordination of nationally-funded research at European level. The project relating to the definition of performance indicators for road pavements within one of COST's domains *(Transport and Urban Development)* was analysed.
- **ERA-NET ROAD:** collaborative project of European National Road Administrations (NRAs) funded by the European Framework Programme (FP7) to develop transnational co-operation for road research
- **AIPCR/PIARC** *(Permanent International Association of Road Congresses)* is the World Road Association that fosters and facilitates global discussion and knowledge-sharing on road and road transport policy and practices within an integrated sustainable transport context.
- **PAS 55** *(Publicly Available Specification)*: British Standards Institution's (BSI) Publicly Available Specification for the optimised management of physical assets. In its publications, it provides clear definitions and a 28-point requirement specification for establishing and verifying a joined-up, optimised, and whole-life management system for all types of physical assets.
- **ISO 55000** *(International Organization for Standardization)*: the international standard for asset management, applicable to any organisation where physical assets are a key or a critical factor in achieving business goals.

2 METHODOLOGY ADOPTED FOR THE ANALYSIS

A common methodology for the analysis was defined with the objective of drawing conclusions from several reports using a common approach and understanding.

The methodology adopted for the analysis was based on three steps:

- selection of reports,
- analysis of the selected reports, and
- drawing conclusions.

The following chart illustrates the methodology used.

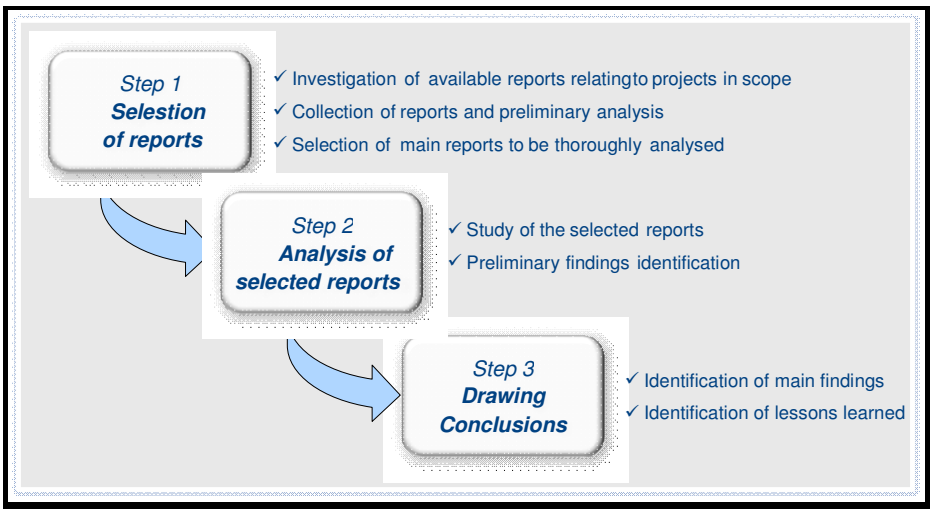


Figure 34: Methodology adopted for the analysis

3 MAIN FINDINGS OVERVIEW

Reference	Main findings	Lessons learned
BEXPRAC	• Differences in expenses calculation were encountered, in particular influenced by depreciation, financing or environmental charges, and organisation overheads. • Differences in expenses were analysed, considering the following major drivers: – traffic levels, – network configuration and complexity, – asset value, – levels of service, – maintenance operation classification, and – users' expectations. • Quantitative data collection was difficult because of incomplete and missing data and a lack of common and shared terminology.	• To combine quantitative analysis with qualitative analysis in order to achieve harmonisation • To consider a long-term approach to road management in order to establish life cycle costs analysis • To take into consideration the role of the user and their expectations as the main stakeholders in the road network • To systematically adopt and use PIARC-recommended vocabulary • To consider M&O drivers highlighted in BEXPRAC for expenses analysis

Reference	Main findings	Lessons learned
COST	• Data harmonisation guaranteed by initial statement of targets and common definition • Data collection conducted via questionnaire • The study provides a full investigation of performance indicators relating to road pavements only • Performance indicators and combined indices can be used as target criteria for life cycle analyses and strongly depend on stakeholders' expectations.	• To focus the road asset management (RAM) strategy initially on single components of the road network in order to avoid complexity • To identify and develop road performance indicators and indices to increase the potential benefits for road stakeholders • To assess the European outlook as a good starting point for AM analysis on the road network • To consider quantitative assessment of performance indicators as a guide, but to take account of the fact that it needs to be constantly supported by qualitative strategies and policies
ERA-NET ROAD	• All components of the road network are involved (pavement, bridges, tunnels, etc.) • Major study drivers are: – stakeholders' expectations – asset performances – key performance indicators • Traditional approaches to road management are inadequate for today's needs because they do not consider stakeholders' expectations. Asset management constitutes a more proactive and suitable approach; • Optimised maintenance strategies are based primarily on historic maintenance information.	• To understand and meet stakeholders' expectations as road owners, road users, and road operators • To analyse road asset performance by investigating asset components and their interactions • To develop high-level strategic road network management based on a long-term view • To analyse historic maintenance information in order to develop a more optimised maintenance approach to the road network

Reference	Main findings	Lessons learned
AIPCR/PIARC	• RAM as an integrated approach to the management of road assets • Performance indicators shall be used to assess and evaluate asset states and as tools for decision-makers. • A set of guides for the implementation of AM, which include: – a simple asset management framework, taking into account owners' objectives and customers' needs, technical tools, and administrative and business arrangements; – a staged implementation of RAM including: inventory, a set of KPI, and some sort of accounting tools; – knowledge of possible pitfalls in order to avoid them.	• To pursue the dialogue with stakeholders, in order to assess their expectations • To define performance indicators and indices to assess and measure the asset's state • To follow AM guidelines underlined by PIARC • To adopt and use PIARC recommended vocabulary and definitions

Reference	Main findings	Lessons learned
PAS 55 and ISO 55000	• PAS 55 first recognised specifications drawn up for AM, which was subsequently converted into a standard by ISO 55000. • The implementation of an AM approach is fundamentally linked to the availability of data relating to condition, performance, costs, and opportunities on road assets. • PAS 55 and ISO 55000 provide a set of guidelines to achieve an optimised AM approach which include considering the whole life cycle of asset.	• To implement an asset management approach as an integral part of the overall business environments of an organisation • To consider measurable continual improvement, to constantly assess assets state • To follow the PAS 55 specification and related ISO 55000 standards for the implementation of asset management policies, strategies and plans, taking into consideration: – the requirements underlined in the PAS 55 reports; – PAS 55 terminology and definitions; – organisational structure of roles, responsibilities and authorities consistent with the achievement of defined AM policy.

4 BEXPRAC REPORT ANALYSIS

4.1 BACKGROUND, GOALS, AND MAIN CONTENT

On the initiative of France, the national road authorities (NRAs) of 13 European countries launched the BEXPRAC survey *(**B**enchmarking of **ex**penditures and **prac**tices of maintenance and operation)* at the CEDR Governing Board meeting on 22 April 2008, in Ljubljana, Slovenia, in an effort to **benchmark the performance of their maintenance and operation (M&O) policies within the framework of CEDR**.

BEXPRAC was the first-ever benchmark of road maintenance and operation costs undertaken at European level.

The study was conducted over the main network of the following 13 European countries: Austria, Belgium-Flanders, Denmark, France, Hungary, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

The main goals of the BEXPRAC study were:

- to obtain references in order to better justify budget allowances;

- to ascertain maintainable levels of service and priorities rules within a given budget;
- to obtain references in order to define performance targets;
- to improve performance levels by sharing best practices.

The study included:

- segmentation of the networks according to specific criteria: climate, traffic conditions, etc.;
- **segmentation of maintenance and operating tasks** to work out common bases in terms of organisation and expenditures.

Overall project activities were subdivided into:

- the **macroscopic or macro module** with a top-down approach, which sought to:
  - compare the overall costs of operation and maintenance in the participating NRAs,
  - explain some of the differences by comparing the distinctive profiles of the networks and the overall levels of service provided;
- the **microscopic or micro module** with a 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.

Both modules 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 learned, self-evident facts and proven statements) which could help each NRA to define its own strategy or policy and possibly facilitate budget negotiations.

4.2 KEY FINDINGS AND LESSONS LEARNED

This section focuses on:

- the key findings of the BEXPRAC report;
- lessons learned

Both the lessons learned and the elements to be further developed to fulfil the project's scope represented a key starting point for the development of the questionnaire on the application of LCC principles that was distributed to participating NRAs.

The main key findings of the BEXPRAC study are given below:

- There are **differences in the way expenses are calculated**, although an effort was made to collect the expense data in a similar format. The main differences are due to the inclusion of depreciation and financing charges, building charges, environmental charges, and organisation overheads;
- There are **clear references** to how traffic levels, network complexity, and levels of service provided to road users have an **impact on the budget required for maintenance and operation expenses**. For a more in-depth analysis, M&O expenses were considered by the following drivers:
  - **Traffic levels**: when traffic levels are taken into account, the variation in expense levels between countries is smaller. This could mean that levels of traffic may be an

important factor in explaining the differences between countries, perhaps even more than the network length and cross-section. High traffic levels may contribute to increase expenses, as highlighted in Belgium-Flanders, the Netherlands, and the United Kingdom case studies. On the other hand, as remarked in the other participating countries, the level of expenses shows little or no relation to traffic, indicating that expenses tend to be more related to the availability of the network rather than to traffic.

- **Network configuration**: differences in network configuration provide differences in expense levels on the road network. Although the survey concentrates on the trunk road network (at least as far as the macro module is concerned), the 13 networks differ considerably from one to another (i.e. Belgium-Flanders, the Netherlands and the United Kingdom road networks include roads with six lanes or more).
- **Network complexity**: there are significant differences in terms of the complexity of the survey networks. The complexity mainly depends on the existence of bridges and tunnels on the road network. The expenses for bridges and tunnels, in fact, are much higher than for linear road sections, and these expenses increase even more for structures in need of maintenance.
- **Asset value**: the value of the assets has a direct impact on the level of maintenance expenses. The value of existing assets was not included in the initial data collection; to overcome this lack of data, a theoretical value had to be calculated in order to verify the relationship between asset values and the cost of M&O.
- **Levels of service**: levels of service are major M&O expense drivers. High road M&O expenses are due to a higher level of service. Since road users judge the networks differently from a network operator, levels of service are measured above all on the basis of user satisfaction.
- **Maintenance operation classification**: the difference in overall expenses is primarily due to differences in expenses for preventive maintenance and rehabilitation and routine operations.
- **User expectations**: economic benefits for the users justify higher expenses levels. BEXPRAC clearly shows that when the level of maintenance is low, road users' satisfaction is also low.

- Almost all organisations involved in the BEXPRAC survey outsource most maintenance and operation activities to other parties. In some cases, such parties are other local government agencies (as in Ireland); in most cases, they are private contractors and only a small group of in-house workers are employed in day-to-day M&O, in particular for routine operations.
- Quantitative data collection is considered difficult, because of:
  - incomplete and missing data in some countries that invalidate data collection and future analysis;
  - difference in terminology, expense allocation rules and maintenance on the road network.

The **main recommendations** (lessons learned) from the BEXPRAC study are:

- to **combine quantitative analysis with qualitative analysis**, seeking harmonisation in order to avoid incomplete and missing data issues that could invalidate future analyses as experimented in BEXPRAC;

- to **highlight an accurate path NRAs need to follow** in order to carry out data collection. This path is underlined by the questionnaire and it guarantees accuracy in data (which road shall be investigated in the road network? What are the common criteria for data collection? What expenses are going to be considered?). This also makes it clear to each NRA what data would be suitable for the investigation of the application of LCC principles;
- to consider a **long-term approach for road sections** for establishing a life cycle cost analysis;
- to take into consideration **users' roles as main stakeholders of the road network**, since social requirements and users' expectations regarding safety and quality of service are constantly rising;
- to systematically **adopt and use vocabulary recommended** by dictionaries and lexicons produced by the World Road Association (PIARC);
- to make sure that **each participating country has the same definition** for maintenance and operation activities;
- to consider **differences between NRAs already highlighted** during the BEXPRAC study and to bypass them in future analyses, if possible;
- to consider the highlighted M&O drivers to explain the variation in expense levels between countries.

5 COST REPORT ANALYSIS

5.1 BACKGROUND, GOALS, AND MAIN CONTENT

COST is an intergovernmental framework for European **Co**operation in **S**cience and **T**echnology, allowing the co-ordination of nationally-funded research at European level.

COST's position paper 'The COST Framework - A cornerstone of the ERA' was approved by the CSO at its 184th meeting on 19 March 2012. The objective of this initiative is to underline COST's valuable role in the **European Research Area (ERA)**, as it has been recognised throughout the years by consecutive reviews and assessments, including the 7th Framework Programme (FP7) mid-term evaluation of COST in 2010.

COST's key features relate to:

- the building of capacity by connecting high-quality scientific communities throughout Europe and worldwide;
- providing networking opportunities for early career investigators;
- increasing the impact of research on policy makers, regulatory bodies, and national decision-makers as well as the private sector.

As a precursor of advanced multidisciplinary research, COST plays a very important role in building a European Research Area (ERA). It anticipates and complements the activities of the EU Framework Programmes, acting as a 'bridge' towards the scientific communities of emerging countries. It also increases the mobility of researchers across Europe and fosters the establishment of scientific excellence in the following nine key domains:

- Biomedicine and Molecular Biosciences,
- Food and Agriculture,
- Forests, their Products, and Services,

- Materials, Physics, and Nano-sciences,
- Chemistry and Molecular Sciences and Technologies,
- Earth System Science and Environmental Management,
- Information and Communication Technologies,
- Transport and Urban Development,
- Individuals, Societies, Cultures, and Health.

In particular, **TUD *(Transport and Urban Development)***, the key domain relating to the present project's scope, fosters research co-ordination in the fields of transport and the infrastructure environment, which play a strategic role in modern society and economy.

This domain is by definition cross-sectoral and multidisciplinary, encompassing a wide range of scientific expertise within transport and land use planning, design, and management activities with a special emphasis on the strong interrelationships between relevant policy fields as well as on all aspects relating to sustainable development.

The domain activities should be innovative and complementary to other European programmes in relevant fields. The aim is to cover both basic and applied research activities including technical and technological developments and their cross-fertilisation that are relevant to policy and decision-making processes.

A significant concern is devoted to activities exploring new research needs and developments. A large component of the domain relates to engineering, construction, and the architecture of urban structures. These cover design methods and technologies for construction, maintenance, operation, rehabilitation, and protection of buildings and infrastructure.

COST is also based on networks, called COST Actions, centred on research projects in fields that are of interest to at least five COST countries.

Every COST Action has an objective, defined goals, and clear deliverables. These are described in a Memorandum of Understanding, signed by participating COST countries.

Current COST Actions within the TUD Domain include COST Action 354 'Performance indicators for road pavements'.

The main objectives of the COST Action 354 'Performance Indicators for Road Pavements' were:

- to define uniform European performance indicators for road pavements, taking into account the needs of road users and road operators;
- to group these individual performance indicators or indices into representative combined performance indices as:
  - functional performance indices (demands made on road pavements by road users),
  - structural performance indices (structural demands to be met by road pavements),
  - environmental performance indices (demands made on road pavements from an environmental perspective).
- to develop a new performance indicator, the so-called 'General Performance Indicator', a mathematical combination of single and/or combined indicators, which provides a first impression of the overall pavement condition at network level. By using this information, a set of guidelines and a maintenance strategy can be derived.

The interest in participation in the action was quite high from the very beginning; a total of 23 European countries and the FHWA/USA took part into the study.

5.2 KEY FINDINGS AND LESSONS LEARNED

COST Action 354 focuses its analyses on road pavements and on the process relating to the design and maintenance of pavements throughout the road network. Furthermore, it investigates the decision making-process relating to pavement road management, basing its overall analysis on performance indicators.

The **main key findings** of the COST Action 354 analysis are summed up below.

- The action was based on a **comprehensive investigation of performance indicators for road pavements** used **across Europe and the US**, taking into account different road categories and pavement types (flexible, semi-rigid, and rigid pavements). The investigations also covered information on each single performance indicator about the target values and limits as well as applied transfer functions, classification systems, and methods of measurement and data collection.
- The harmonisation of data was guaranteed by an initial statement of targets, standards, and common definitions.
- The **collection of information** relating to performance indicators within participating countries was **conducted via questionnaire**; a spreadsheet tool was developed, which also facilitated the calculation of combined and general indicators. The questionnaire was the basis for the overall future analyses.
- The construction of a **quantitative tool to calculate combined indicators** was initiated in order to show rapidly both the effect of changing the weight of the input parameters and the influence of modifications in the recommended combination procedures.
- **An electronic database was implemented** to evaluate the information collected using the questionnaire tool. This was the basis for deciding whether to implement and use new performance indicators for road pavements (data collected are related to the year 2005 and no update has been made since).
- The entire study is based on the following concept: 'the **development of uniform performance indicators and indices for road pavements** is the key to performance evaluation and assessment, and thus to the future planning of the European road network'. It is only the Europe-wide harmonisation of specific road pavement performance indicators that allows international comparisons of existing road pavements from the perspectives of both road users and road operators. Uniform performance indicators could constitute a key prerequisite for future investments in road infrastructure projects at European level. Besides, performance indicators could be used as inputs for PMS (pavement management systems), which have spread worldwide in the last decade, in order to calculate maintenance needs.
- **Performance indicators can be used in particular as target criteria in life cycle analyses** within the context of pavement design and/or systematic road maintenance at national and European levels. Uniform performance indicators permit an evaluation of the effects of different design and maintenance strategies, but they can also be a basis for predicting road performance and for improving and developing new prediction models.

- Given the wide variety of potential users of the COST 354 final approach, the procedure that was developed was designed in such a way that it could be applied in different ways, depending on the type of measurements available and the analysis approach already in place in a given road authority. This approach included:
  - the **identification of a set of performance indices** to represent the following performance indicators (PI) in a dimensionless scale:
    - longitudinal evenness,
    - transverse evenness,
    - macro-texture,
    - friction,
    - bearing capacity,
    - cracking,
    - noise, and
    - air pollution.
  - The **definition of the relationship between each single PI and technical characteristic of the road pavement**, the so-called Technical Parameters (TP) obtained from measurements by a device or collected by other forms of investigation.
  - The **development of four combined performance indices (CPI)**, derived from PIs, in order to characterise the contribution of the pavement structure and condition to the performance of the road asset, which were:
    - safety index,
    - comfort index,
    - structural index, and
    - environmental index.
  - The **development of a general performance indicator (GPI)** to describe the pavement condition concerning different aspects such as safety, structure, riding comfort, and environment. It is a useful decision-making tool for assessing the general condition of the network. It also enables the evaluation of future strategies and subsequent funding requirements;
- Performance indicators evaluation and general performance indicators calculation were based on data analysis. The purpose here was to collect **opinions from different groups of stakeholders** (operators, authorities, and users) concerning the relative importance of each type of performance indicator.

The **main recommendations** (lessons learned) from the COST Action 354 are:

- to focalise the implementation of road asset management strategies, as a first step on **single components of the road network**, such as pavements, in order to reduce its complexity;
- to identify and develop **road performance indicators and indices** in order to increase potential benefits for road stakeholders (operators and road users);
- to take into **consideration the European outlook** in order to identify international road maintenance strategies that could be applied under various conditions and by different administrations; the development of international strategies that can make available new funding systems at European level;
- to consider the identification and development of **performance indicators as major drivers in life cycle analyses**: they can be used as target criteria for the evaluation of design and maintenance strategies;
- to consider the **quantitative assessment of performance indicators** as guidance regarding present and future needs in road pavement design and maintenance, both at national and European level. Nevertheless, quantitative analysis was not considered sufficient, because data collected had to be constantly updated. Decision-making processes need to be implemented starting from a combined strategy relating to both quantitative and qualitative analysis.

6 ERA-NET ROAD REPORT ANALYSIS

6.1 BACKGROUND, GOALS, AND MAIN CONTENT

ERA-NET ROAD is a commitment by 11 NRAs to work in partnership on the development of joint research programmes financed through joint funds.

The aim of the programme is **to improve road safety by increasing the awareness and acceptance of road authorities to implement joint road safety solutions** following the concepts of self-explaining roads and roadsides, taking human factors and human tolerance into consideration. It is envisaged that evaluation tools will be developed to assist road authorities in identifying feasible, valid, and cost-effective solutions focused on rural roads.

The first ERA-NET ROAD Programme, '**ERA-NET ROAD I – Safety at the heart of road design**', was funded from 2005 to 2008 and made considerable progress towards the networking of road research programmes across Europe. In terms of the Commission's four step approach, ERA-NET ROAD has addressed:

- information exchange between national owners of road research programmes,
- definition and preparation of joint activities,
- implementation of joint activities, and
- funding of joint trans-national research programmes.

The second ERA-NET ROAD Programme, **'ERA-NET ROAD II – Effective asset management meeting future challenges'**, is a project funded under the 7th Framework Programme of the European Commission. Its objective is to strengthen the European Research Area in road research by co-ordinating national and regional road research programmes and policies.

The main objective of this joint research programme is to recommend management processes and tools that road directors and operators can use to manage the national road network in a safe, reliable, economic, and sustainable way, in line with stakeholders' expectations by pursuing the following goals:

- to optimise allocation of the available funds in an environment of competing asset maintenance demands;
- to support the change in road network management culture in order to gain a more balanced approach to using maintenance funds and a greater focus on customer needs;
- to embed the culture of collaborative road research in partners' organisations;
- to develop a framework for optimised asset management.

ERA-NET ROAD II is a Coordination and Support Action funded by the 7th Framework Programme of the EC. The ERA-NET ROAD II (ENR2) partners are Austria, Belgium (Flanders), Denmark, Finland, France, Germany, Hungary, Ireland, Lithuania, the Netherlands, Norway, Poland, Slovenia, Sweden, Switzerland, the United Kingdom, with CEDR (Conference of European Directors of Roads) as an associate partner.

As ERA-NET ROAD II will build on the work done to-date, seven projects addressing important aspects of the management of the strategic road networks have been approved in September 2010 (still on-going). The objectives include:

- to determine the requirements and expectations of stakeholders,
- to improve understanding of asset performance,
- the development and use of performance indicators for managing the network,
- cross-asset optimisation.

6.2 KEY FINDINGS AND LESSONS LEARNED

The programme focuses on both the strategic and operational management of the road network.

The **main findings** (or expected findings) of ERA-NET ROAD II are summed up below:

- The research involves **all components of the road network** (pavement, bridges, tunnels, gantries, signs, lighting systems, etc.) and encompasses the whole service life 'from cradle to grave' in order to maximise the potential benefits of road national assets.
- The whole study is built around the following **major drivers**:
  - **Stakeholders' expectations**: managing and meeting the expectations of stakeholders is key to the successful delivery of a road network. It involves issues such as:
    - analysing the relationship between stakeholders' expectations and the levels of service provided,
    - investigating how communication between network operators and stakeholders is managed,
    - identifying the most appropriate way to effectively engage all stakeholders, as well as appropriate techniques and technologies aimed at helping operators to meet identified needs.

- **Asset performance**: managing road assets has become a major challenge because of the growing need to understand how road assets perform under changing conditions, such as increasing traffic volumes or stricter environmental constraints. The main needs are:
    - to assess how different components interact, separately and then together, after finding individual optimum solutions,
    - to understand the impact of these interactions on the road network,
    - to identify a cross-asset management strategy such as a holistic approach, which aims to achieve greater efficiency of budget allocation between different components.
- The starting point for such an analysis shall be existing asset management systems, such as those for pavements or tunnels; best practices from these strategies could be transferred.
- **Key performance indicators (KPIs)**: the development of KPIs within an advanced management strategy allows for the management of European road networks that meet society's needs and stakeholders' expectations. The implementation of KPIs can be done consistently across different road components and in different countries with different road types.

- The whole study emphasises that **the traditional approach to managing roads**, based primarily on the condition of the pavement and structures, **is inadequate for today's needs** as they largely ignore wider issues such as stakeholders' expectations, whole-life costing, sustainability, and the environment. The investigation and analysis of major drivers (as underlined above) allows for the development of a **framework for optimised asset management**: a more proactive approach in which maintenance is carried out before structural deterioration becomes evident.
- The **concept of risk** could be introduced in road asset management strategies to quantify the reliability of the management strategy, as well as considering the interaction between asset components.
- Using **historic maintenance information** allows for the development of optimised maintenance strategy for road assets: case studies can be used to calibrate or verify assumptions made at the design stage relating to whole life cost.

The main recommendations (lessons learned) from ERA-NET ROAD II are:

- **to understand and meet stakeholders' expectations** facilitates the correct management of road assets. Stakeholders are not simply road owners, operators, and users, but also operators of other modes of transport including public transport, local residents, and taxpayers who ultimately fund the network whether they use it or not;
- to **analyse performance of road assets by investigating the interaction between components** such as pavements, bridges, or tunnels and the effects these interactions have on the road network;
- to develop a high-level strategic management of the road network based on a long-term view;

- to **address study results above all to road directors and operators** so that they can manage the national road network in a safe, reliable, economic, and sustainable way, in line with stakeholders' expectations;
- to **analyse historic maintenance information** to develop optimised maintenance strategy, also by developing case studies and then pilot projects that can be used to verify assumptions and identify best practices.

7 AIPCR/PIARC REPORT ANALYSIS

7.1 BACKGROUND, GOALS, AND MAIN CONTENT

The **World Road Association** was founded in France as a non-profit organisation more than 100 years ago on 29 April 1909, some seven months after the First International Road Congress was held in Paris. It was named the **Permanent International Association of Road Congresses (PIARC)**. Although the subjects of concern at the time focused on the design of infrastructure suited to motor vehicles, today, the key issue driving the work is access to safe, environmentally-friendly, and sustainable mobility for all. Moreover, PIARC considers climate change, which seems to be causing increasingly frequent natural disasters, to be a reminder to road authorities of the need to gather and share collective research, knowledge, and experience.

Road administrations across the world seek to address these issues at the highest management and political levels. The World Road Association is participating in this effort through the work of its technical committees, which are composed of experts appointed by member governments. PIARC activities are organised by periodic cycles, based on strategic plans. The World Road Association has been looking into asset management for many years. It is currently being addressed by Technical Committee 4.1 'Management of Road Asset' within the Strategic Plan 2012–15.

The main goals of the AIPCR/PIARC studies were:

- to develop studies and prepare reports and papers on various topics relating to roads and road transport issues;
- to identify best practice and organise seminars on road operations best practice;
- to define guidelines for enhancing access and mobility provided to the community and industry by improved roads.

As of May 2011, the association has 118 national member governments from all over the world. Two-thirds of these members are developing countries (DC) and countries in economic transition.

The World Road Association has formal alliances with other international organisations in the form of Memoranda of Understanding (MoUs). The purpose of the MoUs is to facilitate and strengthen the collaboration between the association and other organisations in addressing issues of local, regional, and international importance. The association has formal alliances with organisations such as:

- **regional organisations of road administrations:** Road Engineering Association of Asia and Australasia (REAAA), Conference of European Directors of Roads (CEDR), Council of Road Directors from Iberia and Latin America (DIRCAIBEA), the Nordic Road Association;

- **international organisations**: World Bank;
- **technical and scientific organisations:** International Transportation Engineers (ITE), International Tunnelling and Underground Space Association (ITA), International Federation of Automotive Engineering Societies (FISITA), Transportation Research Board (TRB).

The main goals of the World Road Association's asset management concept for the period 2012–15 relate to the:

- **assessment of budgetary needs for the maintenance of road infrastructure**: with the clear aim of reviewing approaches and practices developed by countries for the assessment of budgetary needs for the maintenance of road infrastructure. Moreover, it seeks to define a common framework allowing comparison of different countries in terms of the cost of the maintenance of road pavements for given categories of comparable roads;
- **optimisation of maintenance strategies for multiple assets of road networks**: with the clear aim of investigating the approaches implemented for determining maintenance strategies aimed at making the best use of allocated budgets;
- **balancing of environmental and engineering aspects in road network management**: with the aim of investigating, on the basis of case studies, how environmental aspects are taken into consideration, complementing engineering aspects associated to road management strategies applied to road networks;
- **Road Assets Management Manual**: with the aim of designing and starting the development of a Road Assets Management Manual, based on previous work cycles.

Furthermore, previous documents relating to the investigation on the application of LCC principles were analysed:

- 'Asset Management Principles', from PIARC Technical Committee C 4.1 'Management of Road Infrastructure Assets', during PIARC Strategic Plan 2004–07;
- 'Asset Management for Roads', from PIARC Technical Committee on Road Management C 6, during PIARC Strategic Plan 2008–11.

7.2 KEY FINDINGS AND LESSONS LEARNED

This section focuses on:

- key findings from AIPCR/PIARC AM-related reports;
- lessons learned (recommendations) and elements to be further developed to fulfil the project's scope.

Both the lessons learned and elements to be further developed represented a key starting point for the development of the questionnaire on the application of LCC principles that was distributed to participating NRAs.

The **main key findings** of the AIPCR/PIARC studies are:

- **Effective asset management** must not be regarded as a system, but rather as an approach to managing infrastructures embodying a **framework** within which various systems can be operated in order to obtain optimisation, an effective business model, and systematic communication with stakeholders.

- **Road asset management (RAM)** is **an integrated approach to the management of road assets,** optimising many different aspects of the road asset, such as components, goals, stakeholders, outcomes, etc. In each case, the optimisation should be based on the evaluation of the most important aspects. Due to time and cost restraints, it is practically impossible to take all relevant aspects into account. The optimisation should be planned and prepared so that the necessary data is available when needed. Otherwise, the optimisation will be halted because of the shortage of time, rather than for cost/benefit reasons.
- **Performance indicators** are used to assess the actual state of the asset, to define goals, and to make the adequate choice of enablers to provide the results to be achieved; they are both measurement tools used by technicians to manage their assets and decision-making tools to manage a series of assets.
- Road administrations seeking to implement the **asset management framework** should take into account the **additional guidance** provided below, by the following three basic rules:
  - Start with the establishment and integration of a simple asset management framework. The main components of an asset management framework are:
    - **Owners' objectives and customers' needs**: they are the main means of identifying goals and desired outcomes.
    - **Technical tools**: they need to be adjusted, purchased or developed to manage inventory data, measure and store condition data, and analyse maintenance and development strategies. Moreover, they have to be constantly adjusted to ensure that changes in enablers are accommodated in the pursuance of the desired outcome within a constantly developing environment.
    - **Administrative and business arrangements**: they are closely connected to each other and they are also frequently mixed and intertwined.
  - Prepare for the gradual implementation of RAM: successful asset management implementation requires gradual development; this includes:
    - **having an infrastructure inventory and knowing the condition of the infrastructure,** and using the measurement of assets covered and performance indicators to assess the impact of management strategies;
    - development of **accounting tools** relating to infrastructure condition and ride comfort.
  - Be aware that there will be many pitfalls and cul-de-sacs, such as:
    - attempting to **include too many assets** in the umbrella framework; for this reason, the level of detail and categorisation must be considered carefully;
    - **data collection with high demands** on precision; high detailing can absorb most of the budget leaving little resources for analysis and use of the data;
    - **unclear performance measures**, or measures that can be manipulated; it may result in undesired outcomes.

The **main recommendations** (lessons learned) from the AIPCR/PIARC studies are:

- to **look for an optimised asset management approach** following the **AM framework** defined by the World Road Association, which includes:
  - owners' objectives and customers' needs,
  - technical tools,
  - administrative and business arrangements;
- to **pursue the dialogue with stakeholders**, mostly in terms of outcome, perceived value, and expectations;
- to **define performance indicators and indices** to assess actual state of the asset and to measure the appropriate choice of enablers giving the achieved results;
- to avoid identified and already documented pitfalls;
- to systematically **adopt and use vocabulary recommended** by dictionaries and lexicons produced by the World Road Association (PIARC).

8 PAS 55 REPORT ANALYSIS

8.1 BACKGROUND, GOALS, AND MAIN CONTENT

PAS 55 is **the British Standards Institution's (BSI) p**ublicly **a**vailable **s**pecification **for the optimised management of physical assets**; it provides clear definitions and a 28-point requirements specification for establishing and verifying a joined-up, optimised, and whole-life management system for all types of physical assets. It is currently a UK specification, although it is structured to align with other commonly used standards and it is expected to become a full ISO standard; the International Standards Organisation (ISO) has accepted PAS 55 as the basis for development of the new ISO 55000 series of international standards.

This publicly available specification was first published in 2004 in response to a demand from industry for a standard for asset management. It is applicable to any organisation where physical assets are a key or a critical factor in achieving its business goals. In 2008, PAS was updated in order to reflect the increasing international consensus about required good practices in management of such physical assets.

PAS 55 has been developed in consultation with a large number of international organisations and individuals from a wide range of industries that are active and proficient in the field of asset management.

PAS 55 has proven successful, with widespread adoption in utilities, transport, mining, processing, and manufacturing industries worldwide. The 2008 update (PAS 55:2008) was developed by 50 organisations from 15 industry sectors in ten countries.

Moreover, PAS 55 enables the integration of all aspects of the asset lifecycle: from the first recognition of a need to design, acquisition, construction, commissioning, utilisation or operation, maintenance, renewal, modification, and/or ultimate disposal.

The main goals of PAS 55 are:

- to **ensure consistency** with other related management system standards and to facilitate its alignment or integration. It was considered that asset management would be best standardised as a specification, with the information on implementing asset management distilled into key requirements;
- to **underline principles** for implementing asset management plans;
- to define KPI for monitoring asset conditions;
- to define asset management guidelines and strategies.

8.2 KEY FINDINGS AND LESSONS LEARNED

This section focuses on:

- key findings from the PAS 55 report;
- lessons learned (recommendations) and elements to be further developed to fulfil the project's scope.

Both the lessons learned and elements to be further developed represented a key starting point for the development of the questionnaire on the investigation of the application of LCC principles that was distributed to participating NRAs.

The **main key findings** of PAS 55 are the following:

- PAS 55 is the first recognised specification drawn up for asset management.
- PAS 55 defines asset management as 'systematic and co-ordinated activities and practices through which an organisation optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their lifecycles for the purpose of achieving its organisational strategic plan.'
- The **organisational strategic plan** is the starting point for the development of the asset management policy, strategy, objectives, and plan. An asset management system is, in fact, primarily designed to support the delivery of the organisational strategic plan in order to meet the expectation of a variety of stakeholders.
- **Data** on condition, performance, activities, costs, and opportunities should already be **available** for laying the foundations of successful implementation. It is also important that intangible assets are taken into account regarding reputation, image, and social impact. From a **financial perspective, information about lifecycle costs, capital investment criteria, and operating cost is essential**;
- A **disciplined approach to the implementation of asset management** enables organisations to maximise value and deliver their strategic objectives through managing their assets over the whole life cycle of the assets.
- An optimised approach to asset management takes into consideration **the whole life cycle of assets**. The **major benefits of optimised life cycle asset management** include:
  - enhanced **customer satisfaction** from improved performance and control of product or service delivery vis-à-vis the required standards;
  - **improved** health, safety, and environmental **performance**;

  - optimised return on investment and/or growth;
  - **long-term planning**, confidence, and performance sustainability;
  - an ability to demonstrate **best value for money** within a constrained funding regime;
  - evidence, in the form of **controlled and systematic processes**, to demonstrate legal, regulatory, and statutory compliance;
  - **improved risk management and corporate governance** and a clear audit trail for the appropriateness of decisions taken and their associated risks;
  - **improved corporate reputation** in the form of **enhanced shareholder value, improved marketability of products/services**, greater user satisfaction and a more efficient and effective procurement from the supply chain;
  - the ability to demonstrate that **sustainable development** is actively considered within the management of the assets over their life cycles.

- Asset management enabling elements are:
  - an organisational structure that facilitates the implementation of AM principles with clear direction and leadership;
  - staff awareness, competency, commitment, and cross-functional co-ordination;
  - adequate information and knowledge of asset condition, performance, risks and costs, and the interrelationships between these.

- Delivering the **best value for money** in the management of physical assets is complex and involves careful consideration of:
  - trade-off between performance, cost, and risks over all stages of the assets' life cycles;
  - different conflicting factors to manage, such as short-term versus long-term benefits, expenditures versus performance levels, planned and unplanned availability, capital costs versus operating expenditures;
  - different levels at which assets can be identified and managed.

- The **human asset perspective** is necessary in order to get a good view of motivation, expertise, and the roles and responsibilities of the people and leadership teams involved in the organisation. PAS 55 is designed to help organisations display full asset management competence by meeting a particular set of requirements. Requirements address **good practices** rather than **best practices** in each area.

- PAS 55 can be applied to:
  - **any asset-intensive business**, where significant expenditure, resources, performance objectives, and/or risk are associated with the creation/acquisition, utilisation, maintenance, or renewal/disposal of assets;
  - **any organisation that has, or intends to manage or invest in, a significant portfolio of assets**, or where the performance of asset systems and the management of assets are central to the effective delivery of service/product or other business objectives;

- any organisation where there is a **business or public accountability** requirement to demonstrate best value in the safe management of assets and provision of associated services.

The **main recommendations** (lessons learned) from PAS 55 are:

- to implement the asset management approach as an **integral part of the overall business environment of an organisation**, it is vital in order to be successful;
- to consider **measurable continual improvement** an integral part of the asset management approach; AM is in fact based on the concept of the PDCA cycle (Plan-Do-Check-Act):
  - **plan**: establish the asset management strategy, objectives and plans necessary to deliver results,
  - **do**: establish the enablers for implementing asset management and other necessary requirements and implement the AM plan,
  - **check**: monitor and measure results, recording and reporting them constantly,
  - **act**: take actions to ensure that asset management objectives are achieved and to continually improve the asset management system and its performances;
- to **follow PAS 55** for the implementation of asset management policies, strategies and plans, which includes:
  - to **establish asset management policies and strategies** in accordance with the requirements of PAS 55,
  - to use PAS 55 terminology and definitions,
  - to **establish and maintain an organisational structure** of roles, responsibilities and authorities, consistent with the achievement of defined asset management policy, strategy and plans according to PAS 55.

9 ISO 55000 REPORT ANALYSIS

9.1 BACKGROUND, GOALS, AND MAIN CONTENT

The 'ISO 55000' family is the new international set of standards for asset management. It is based on PAS 55 achievements. ISO 55000 promises to be a widely recognised and adopted international standard for asset management.

PAS 55 (the British Standards Institution's requirements specification for the optimal management of physical assets) is being used as a basis by the International Standards Organisation (ISO) for the first ever international standard for asset management. This will be published in 3 parts:

- ISO 55000 will provide the overview, concepts, and terminology in asset management;
- ISO 55001 will specify the requirements for good asset management practices: an 'Asset Management System';
- ISO 55002 provides interpretation and implementation guidance for such an asset management system.

The family of standards is expected to be aligned with, and be capable of being integrated into, other major management systems specifications. These include ISO 9001 for quality

management, ISO 14001 for environmental management, OHSAS 18000 for occupational health and safety, and ISO 31000 for risk management. The ISO 55000 family is also one of the first management system standards to implement the new ISO Guide 83, providing a consistent basis for all management systems and enabling better integration and co-ordinated monitoring, audit, and certification.

The standards are currently in the 'Committee Draft' stage, being reviewed by participating countries. Subject to the feedback and committee acceptance of any changes, the project is expected to anticipate final drafting and editing during 2012–13, with full publication in early 2014.

9.2 KEY FINDINGS AND LESSONS LEARNED

Since ISO 55000 standards emerged on PAS 55 specifications, the **findings and lessons learned from ISO 55000 match the ones coming from PAS 55 analysis**, described in section 8.2.

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