UNECE

Tools for asset management: TEM recommendations for road operators

Trans-European North-South Motorway (TEM)

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Tools for road asset management: TEM recommendations for road operators

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United Nations Economic Commission for Europe

The United Nations Economic Commission for Europe (UNECE) is one of the five United Nations regional commissions. It was established in 1947 with the mandate to help rebuild post-war Europe, develop economic activity and strengthen economic relations among European countries, and between Europe and the rest of the world.

During the Cold War, UNECE served as a unique forum for economic dialogue and cooperation between East and West. Despite the complexity of this period, significant achievements were made, with consensus reached on numerous harmonization and standardization agreements.

Since the early 1990s, the organization has focused on assisting the countries of Central and Eastern Europe, the Caucasus and Central Asia with their transition process and their integration into the global economy.

Today, UNECE supports its 56 member States in Europe, Central Asia and North America in the implementation of the 2030 Agenda for Sustainable Development with its Sustainable Development Goals (SDG). UNECE provides a multilateral platform for policy dialogue, the development of international legal instruments, norms and standards, the exchange of best practices, and economic and technical expertise, as well as technical cooperation for countries with economies in transition.

Offering practical tools to improve people's everyday lives in the areas of environment, transport, trade, statistics, energy, forestry, housing and land management, many of the norms, standards and conventions developed in UNECE are used worldwide, and a number of countries from outside the region participate in UNECE's work.

The multisectoral approach of UNECE helps countries to tackle the interconnected challenges of sustainable development in an integrated manner, with a transboundary focus that helps devise solutions to shared challenges. With its unique convening power, UNECE fosters cooperation among all stakeholders at the country and regional levels.

Transport in UNECE

The UNECE Sustainable Transport Division is the secretariat of the Inland Transport Committee (ITC) and the ECOSOC Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals. The ITC and its 20 working parties, as well as the ECOSOC Committee and its sub-committees are intergovernmental decision-making bodies that work to improve the daily lives of people and businesses around the world, in measurable ways and with concrete actions, to enhance traffic safety, environmental performance, energy efficiency and the competitiveness of the transport sector.

The ECOSOC Committee was set up in 1953 by the Secretary-General of the United Nations at the request of the Economic and Social Council to elaborate recommendations on the transport of dangerous goods. Its mandate was extended to the global (multi-sectoral) harmonization of systems of classification and labelling of chemicals in 1999. It is composed of experts from countries which possess the relevant expertise and experience in the international trade and transport of dangerous goods and chemicals. Its membership is restricted in order to reflect a proper geographical balance among all regions of the world and to ensure adequate participation of developing countries. Although the Committee is a subsidiary body of ECOSOC, the Secretary-General decided in 1963 that the secretariat services would be provided by the UNECE Transport Division.

ITC is a unique intergovernmental forum that was set up in 1947 to support the reconstruction of transport connections in post-war Europe. Over the years, it has specialized in facilitating the harmonized and sustainable development of inland modes of transport. The main results of this persevering and ongoing work are reflected, among other things, (i) in 58 United Nations conventions and many more technical regulations which are updated on a regular basis and provide an international legal framework for the sustainable development of national and international road, rail, inland water and intermodal transport, including the transport of dangerous goods, as well as the construction and inspection of road motor vehicles; (ii) in the Trans-European North-South Motorway, Trans-European Railway and the Euro-Asia Transport Links projects, that facilitate multi-country coordination of transport infrastructure investment programmes; (iii) in the TIR system, which is a global customs transit facilitation solution; (iv) in the tool called For Future Inland Transport Systems (ForFITS), which can assist national and local governments to monitor carbon dioxide (CO2) emissions coming from inland transport modes and to select and design climate change mitigation policies, based on their impact and adapted to local conditions; (v) in transport statistics – methods and data – that are internationally agreed on; (vi) in studies and reports that help transport policy development by addressing timely issues, based on cutting-edge research and analysis. ITC also devotes special attention to Intelligent Transport Services (ITS), sustainable urban mobility and city logistics, as well as to increasing the resilience of transport networks and services in response to climate change adaptation and security challenges.

In addition, the UNECE Sustainable Transport and Environment Divisions, together with the World Health Organization (WHO) – Europe, co-service the Transport Health and Environment Pan-European Programme (THE PEP).

Finally, since 2015, the UNECE Sustainable Transport Division has provided the secretariat services for the Secretary General's Special Envoy for Road Safety, Mr. Jean Todt.

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADB	Asian Development Bank
AM	Asset Management
AMS	Asset Management System
AMP	Asset Management Plan
AUSTROADS	Organization of road transport and traffic agencies in Australia and New Zealand
CEDR	Conference of European Directors of Roads
CIP	Capital Investments Projects
IRF	International Roads Federation
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
NTIS	National Traffic Information Service
OECD	Organisation for Economic Cooperation and Development
O&M	Operation and Maintenance
PIARC	World Road Association
PPP	Public–Private Partnership
PPIAF	Public–Private Infrastructure Advisory Facility
SAMP	Strategic Asset Management Plan
TAMP	Transportation Asset Management Plan
TEM	Trans-European North–South Motorway Project
TQM	Total Quality Management
TVM	Total Value Management
UNECE	United Nations Economic Commission for Europe

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Executive summary

Public sector organizations are increasingly being subjected to both legislative and competitive pressures forcing them to reconsider their relationships with users and customers in order to develop a more overt customer orientation (as the primary driver of organizational performance). The creation of value supports the development of a customer orientation and is a requirement to which public sector organizations are increasingly adapting. This applies to all sectors of the economy, including the road sector.

The main focus of this report is to compile an overview of international best practice in comprehensive asset management activities and to share the experiences and examples of TEM member countries to support the process of continual improvement of existing systems among the participating countries.

Asset management has become a popular approach for asset-heavy industries, affecting the organization and management of a number of companies and institutions from multiple sectors of the economy.

This approach is also increasingly popular in the transport infrastructure sector, where planning and scheduling of works or services requires not only the delivery of multifaceted value for road network users, but also for other stakeholders from the general public to particular interest groups (i.e., transport and logistics).

Asset management should be understood as a value creation process which aligns the strategic, tactical and operational levels of an organization's management through technical, engineering, and business principles and practice driven by economic rationale.

As asset management is a value creation process, an asset management system can be described as an organization's value chain and the necessary procedures, systems and competencies enabling the organization to carry out its steps and activities in logical sequence to ensure that operational activities fulfil the strategic objectives of the organization and its customers' needs.

Finally, asset management tools can be defined as an aggregated and interrelated system of procedures, methodologies, data, software and hardware applied to support the efficiency and effectiveness of the asset management value creation process.

The relationships between these concepts are reflected in what is known as the balanced scorecard, proposed as a basic performance management framework for road authorities.

Apart from this management framework, this report also presents alternative approaches and comprehensive knowledge regarding performance measures that should be used by road authorities to assess their outputs and outcomes at the network and organizational levels.

Moreover, this analysis highlights the most relevant procedures, processes and models (tools) that should be incorporated in the performance assessment and in the planning and programming of projects and activities.

Ultimately this report provides a benchmarking analysis of TEM member countries to better understand the region's maturity in terms of the above approach. To make this assessment comprehensive, the authors applied the framework elaborated by the Conference of European Road Directors which covers the five most relevant elements of a road authority – its approach to strategy and planning, asset information strategies, stakeholders and customers management, risk management, and organization and human resources management.

Section 1: The need for comprehensive road asset management

1.1. Context of the TEM Project

The UNECE Trans-European Motorways (TEM) Project is the sub-regional cooperation among Central, Eastern and South European member countries with the aim to:

- Facilitate road traffic in Europe
- Improve the quality and efficiency of transport operations
- Balance existing gaps and disparities between motorway networks in Western, Eastern, Central and South-Eastern Europe
- Assist in the integration process of European transport infrastructure systems

According to the recent TEM Strategic Plan for the years 2017-2021, the Project's vision is to serve the role of a substantive partner for UNECE and the Inland Transport Committee in the field of road infrastructure management, and to support TEM member countries in achieving the United Nations Sustainable Development Goals.

The mission of the Project has been defined as creating a forum for cooperation among governments to establish standards, good practices and guidelines for systemic and strategic topics in road infrastructure management.

To achieve these goals, the TEM Project Steering Committee adopted a set of strategic initiatives covering the following areas:

- Environmental protection
- Organization and financing of roads and motorways
- Information systems for the management of road infrastructure
- Innovations in road infrastructure management
- Road safety

1.2. Tools for road asset management: TEM recommendations for road operators report

The main focus of this report is to analyse international best practice for carrying out comprehensive asset management activities and to share experiences and examples from TEM member countries to support the process of continual improvement of existing systems within the participating countries.

Public sector organizations are increasingly being subjected to both legislative and competitive pressures forcing them to reconsider their relationships with users of their services – who can be defined here as customers in a business sense – in order to develop a more overt customer orientation (as the primary driver of organizational performance). The creation of value supports the development of a customer orientation and is a requirement to which more public sector organizations are adapting. This applies to all sectors of the economy as well as to the road sector.

In modern society, road infrastructure has become an essential part of daily life. Individual road users, logistics companies and public transportation agencies expect reliable and safe road infrastructure to carry out their transportation or wider mobility operations, moving goods and people.

Road authorities need to meticulously plan, build, maintain and operate the road infrastructure to create the abovementioned value for their customers.

To achieve these goals, road authorities must adopt an appropriate value delivery system which will be based on:

- Fact-based (data-driven) project selection
- Streamlined project delivery
- Making the most of existing roads
- Improving capabilities
- Accurate funding and finance

Based on contemporary international best practice to improve asset life cycle management, the usage of sophisticated tools supporting asset management is required.

These tools should, however, be understood not only as IT solutions but in a wider sense enablers to carry out (1) all processes included in an organization's value chain (e.g., asset management policy, strategic and operational asset management plans or analytical tools for risk, demand and supply management); and (2) all activities regarding the governance, management and operational frameworks of an asset's owners to support appropriate planning and performance management.

For these reasons, this report presents the following:

- The relationships between key asset management processes exercised by road authorities and the necessary supporting tools
- A description of tools and methodologies for network performance management and works and services planning
- A maturity assessment in comprehensive asset management for the TEM Project region

1.3. Asset management, asset management systems and asset management tools

Asset management has become a popular approach for asset-heavy industries affecting the organization and management of a number of companies and institutions from multiple sectors of the economy.

This approach is also increasingly popular in the transport infrastructure sector, where planning and scheduling of works or services requires not only the delivery of multifaceted value for road network users, but also for other stakeholders from the general public to particular interest groups (i.e., transport and logistics).

Unfortunately, quite often people confuse the terms asset management and asset management systems, and tend to limit their understanding of asset management systems to a more or less sophisticated set of IT tools.

It is therefore important to clarify what these terms mean and how they should be understood.

1.3.1. Asset management

The main purpose of each organization – whether a private company or public institution – is to provide value for their customers.

Value is something that customers and stakeholders expect an organization will deliver through the organization's services or products. Organizations are therefore required to understand what is valued by their customers and to organize the whole process from understanding customers' needs and expectations, through creation and delivery of products or services, to the receiving and interpreting of feedback from the customers to improve performance within the next cycle.

What has been described above is a value creation process that organizations are able to carry out using their assets – the physical or non-physical resources which are valued by the customers and which create an organization's competitive advantage.

Asset management should therefore be understood as a value creation process which aligns the strategic, tactical and operational levels of an organization's management through technical, engineering, and business principles and practice driven by economic rationale.

An appropriate combination of management levels, principles and practices is made possible through the asset management system.

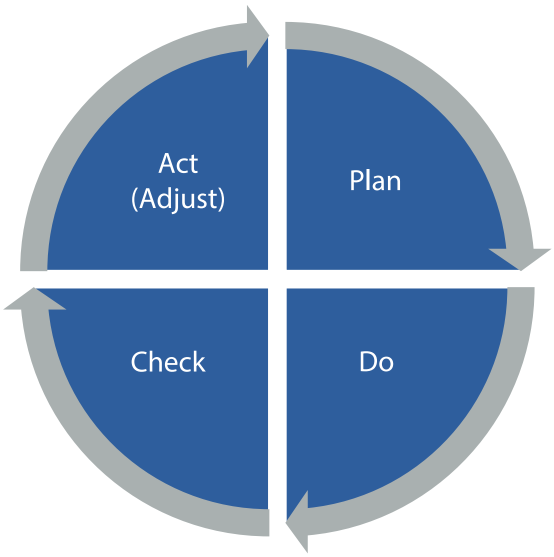
1.3.2. Asset management system

According to the international standard ISO 55000, an asset management system is a set of interrelated and interacting elements of an organization, the function of which is to establish the asset management policy and asset management objectives, as well as the processes needed to achieve those objectives.

The selected processes should therefore enable an organization to understand customer needs and expectations, create and deliver a product and/or service, and collect enough data and information to measure the achieved performance while simultaneously serving as a basis for further improvements.

The general framework for designing the appropriate sequence of processes can be reflected by the popular approach of the Deming Cycle, also known as the Plan-Do-Check-Act (Adjust) cycle (PDCA).

Figure 1
Plan-Do-Check-Act (Adjust) framework



Source: W. Edwards Deming, The New Economics for Industry, Government and Education (Boston, MIT Press, 1993).

The outcome of the planning phase ("Plan") is to establish objectives and furthermore operational processes to deliver desired results.

The phase "Do" is focused on the execution of the planned activities to achieve the given objectives.

During the "Check" phase, the data and results gathered from the previous phases are evaluated. Data is compared to the expected outcomes to identify any similarities or differences between what was planned and what has been achieved. This phase may also be called as "S – study" as it helps to determine the reasons for any observed deviations from the assumed outcomes.

Finally, the phase "Act" (or, even better, "Adjust") is focused on the processes and overall system improvements, building on the results of the performance evaluation done in the preceding step.

PDCA should, however, only be an inspiration for the more detailed design and selection of the system of internal business processes.

As asset management is a value creation process, an asset management system can be described as an organization's value chain and the necessary procedures, systems and competencies enabling the organization to carry out its activities in a logical sequence to ensure operational activities satisfy the strategic objectives of the organization and its customers' needs.

The generic concept of the value chain[1] requires some adjustments for public sector organizations like road authorities, which tend more toward managing road networks through subcontractors than producing services or works by themselves.

Understanding the essence of the value chain for road authorities requires understanding the needs and expectations of communities, tax payers, road users and other stakeholders, translating those needs and expectations into more technical language that makes it possible to plan and programme relevant activities (capital, maintenance and operational interventions in the road network), contracting these activities through the supply chain, supervising the works and services delivery process and, finally, assessing if the quality of the provided works and services is sufficient to achieve satisfactory performance both throughout the whole network and for each individual asset when compared to the expected outcomes.

While the third phase of the above approach seems to be well established among road authorities – essentially their most exercised competency – usually planning and performance evaluation processes require the application of more sophisticated tools. This is because road authorities are responsible not only for the delivery of the technical standards of particular assets defined in formal documents but also for providing more diverse outcomes from the whole network and its life cycle perspective, including both economic and customer experience factors.

1.3.3. Asset management tools

Apart from defining within the value chain what an organization should do to deliver expected outcomes (works, products, services), the value creation process is supported by a set of asset management tools that enable and facilitate how particular outputs and outcomes are to be delivered.

For each process, any organization should define exact operational procedures, ensure necessary competencies and implement dedicated systems. The table 1 below presents some examples.

Figure 2
Sequence of road authority primary actions

Source: Andrzej Maciejewski (2020).

[1] Michael E Porter, *Competitive advantage: creating and sustaining superior performance* (New York, Free Press, 1985).

Table 1
Example of asset management system processes and tools

High level processes	Operational processes & procedures	Information systems	Competencies
Performance evaluation	■ Data collection ■ Condition assessment ■ Performance assessment	■ Performance management framework ■ Data warehouse ■ IT systems architecture	■ Engineering ■ Economic ■ Managerial ■ Legal ■ IT
Planning and programming	■ Determination of treatment scenarios ■ Optimized projects selection	■ Traffic model ■ Deterioration model ■ Risk matrix	■ Engineering ■ Economic ■ Managerial
Works and services life-time delivery	■ Outsourcing strategy ■ Procurement & contracting standards	■ Building Information Modelling ■ Projects management	■ Engineering ■ Legal ■ Managerial

Source: ibid., Andrzej Maciejewski.

Asset management tools can therefore be defined as aggregated and interrelated procedures, methodologies, data, software and hardware applied to support the efficiency and effectiveness of the asset management value creation process.

The main drivers for developing asset management tools (AMT) include:

1) Improved cost-efficiency of physical asset management (e.g., roads and bridges) – AMT provide data and tools to transform these data into useful information for all relevant management levels to optimize priorities with respect to maintenance works and services, capital projects, or both maintenance and capital expenditures, as well as delivery time.

2) Improved effectiveness and performance – AMT automate the traditional way of carrying out operational processes and procedures, thus helping to improve an organization's response times to customer needs. Moreover, AMT support the management of contractors through the ability to report accurately on defined performance measures (key performance indicators).

3) Risk reduction – Through appropriate procurement and contracting standards, organizations can manage their delivery process risks including:

   a) optimal in-house/outsourcing proportion

   b) monopolization of the services/works market

   c) cost and quality of works and services delivery

1.4. Total value management

Adopting an asset management approach and implementing a comprehensive asset management system within the organization (e.g., road authority) requires both top-down and bottom-up activities.

Top-down means a sound understanding of internal and external strategic contexts of an organization, while bottom-up capabilities refer to:

- Operational processes and procedures
- Systems supporting and automating the above procedures
- Competencies reflected within the structure of an organization, job descriptions and the actual capacities of employees

It is not enough to simply have these two approaches implemented or reflected in the organization structure. It is necessary to ensure that they are aligned, meaning that all necessary operational activities, procedures, systems and competencies are designed to fulfil strategic goals and objectives valued by the customers. What is required is a comprehensive management system that identifies and satisfies the needs and expectations of consumers better than the competitors (in this case perhaps seen as other government bodies competing for funding)[2].

Technical quality – as in total quality management (TQM) – addresses aspects of quality with reference to the functions a product must perform, though this is only one of the many value characteristics that need to be considered by an asset manager (including road asset managers)[3].

[2] Competition, as observed in the private sector, may not seem to be applicable for road authorities or more broadly public sector organizations, but taking into account competition in terms of access to taxpayer funds or state budget funds, the relevance of this term should be accepted.

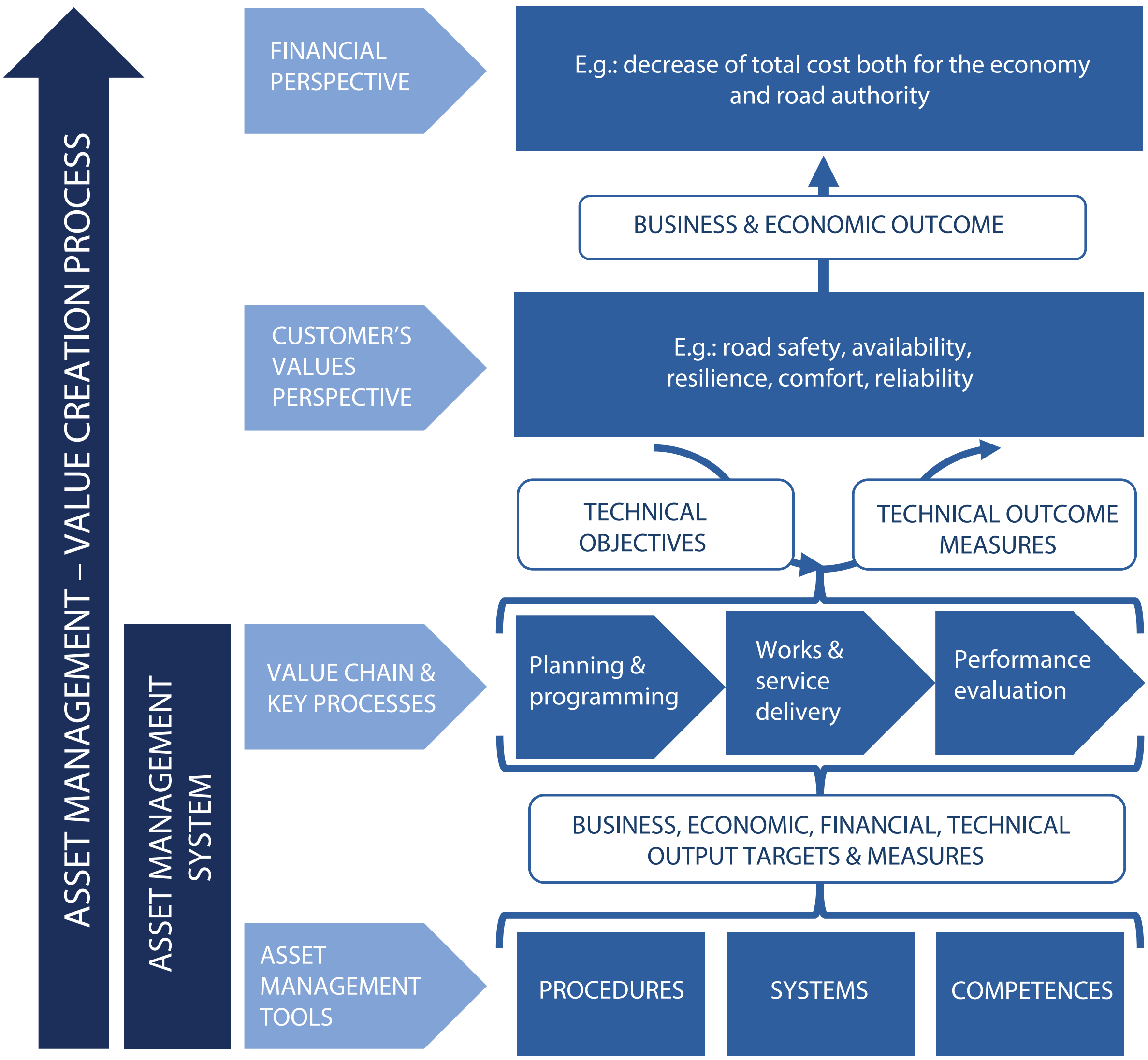
[3] Biren Prasad, "Total Value Management: a knowledge management concept for integrating TQM into concurrent product and process development", *Knowledge and Process Management*, vol. 8, No. 2 (April/June 2001).

With conventional TQM processes, it is difficult to address all aspects of the value expected by customers and stakeholders, such as (in the road sector):

- Cost-efficiency
- Effectiveness and performance
- Safety and security
- Network and assets resilience
- Accessibility, connectivity and availability

The response to these challenges could be total value management (TVM). TVM efforts can be achieved through implementation of the asset management approach including all necessary processes, procedures and tools being part of an asset management system (an organization's value chain) to ensure that all detailed activities are aligned and lead to the creation of the expected value (the essence of asset management), as depicted in Figure 3.[4]

Figure 3
Asset management process, system and tools visualized on the balanced scorecard



Source: ibid., Andrzej Maciejewski.

[4] Alternatively, instead of implementation of TVM through comprehensive asset management, organizations may wish to work on value creation and management through other approaches like 5P, recently presented by McKinsey: P – portfolio strategy and products (assets in the case of roads), P – people and culture, P – processes and systems, P – performance metrics, P – positions and engagements. The distinction between different approaches may, however, be misleading as the essence is still to deliver value to the customer. Sebastian Leape and others, "More than a mission statement: how the 5Ps embed purpose to deliver value", McKinsey Quarterly, 5 November 2020.

Section 2: Key road asset management processes and supporting tools

To carry out a useful benchmarking analysis of asset management tools within TEM member countries, it is first necessary to define the list of processes common for each road authority. This will ensure consistency with the general asset management system presented in Table 1 and consistency in the benchmarking exercise.

To define the list of processes it is convenient to use the value chain approach presented and described in sub-section 1.3. of this document.

2.1. High-level processes for road asset management and groups of tools

Since a national road authority makes its value proposition by exploiting road-related assets to create its services, the road authority's comprehensive set of business processes for asset management comprise the following primary activities:

- Performance evaluation and adjustment
- Planning and programming (strategic and operational planning)
- Works and services delivery (plan execution)

This refers to the general framework presented in Figure 1 (PDCA). Although in that generic approach the process starts at the planning phase, usually planning and programming are preceded by an analysis of the condition and performance of current assets as a basis for planning further activities.

2.1.1. Performance evaluation and adjustment

The initial phase in the asset management approach is to verify if the asset portfolio (i.e., road network) and each individual asset (i.e., section of road, bridge or other assets from the inventory) meet current legal requirements, considering the strategic goals and operational objectives.

This process makes it possible to assess if the execution of the plan was successful and yielded the expected outcomes. Moreover, in this phase the road asset manager (understood here as a road authority) should foresee how the assets will function in the future; this allows for the assessment of the future performance of the assets.

Future performance may be determined using failure history analysis (i.e., a failure tree analysis) and an appropriate deterioration model. Having estimated future performance, the road asset manager is able to determine the future service and residual life of the asset and assets portfolio.[5]

Based on international best practice[6], this phase of asset management requires a documented strategy in terms of asset information and documented asset information standards (groups of tools for performance evaluation and the adjustment process).

The end goal of asset information strategy is to assess the current capability of the assets to provide the required service.

This strategy defines how an organization intends to acquire, store, utilize, assess, improve, archive and delete asset information. It takes into account the life cycle costs of the provision of asset information and the value the information adds to the organization in terms of improved decision-making and support for the delivery of asset management activities. The asset information strategy may include:

- The types of decisions which will be supported by the collected data and information
- The approach to defining information requirements (considering, for example, the cost of providing the information)
- The technology and software to be used and the logical data model
- Identification of the main outcomes and functionality required from asset information systems
- Information about integration of different systems and the strategy for the migration of data and users to new systems (IT architecture – see Section 3 of this report)

[5] It is relevant to distinguish between the condition and performance of an asset. An asset's performance is directly related to its ability to provide the required level of service, while its condition is related to the physical state of the asset which may or may not affect its performance.

[6] The Institute of Asset Management, *Asset management - an anatomy*, ver. 3, December 2015. Also Institute of Public Works Engineering Australasia, *International Infrastructure Management Manual,* 5th ed. (n.p., 2015).

Asset information standards ensure that asset information is collected, categorized and provided at agreed levels of detail and on agreed timescales. This may include:

- Classification of assets in an agreed hierarchy
- Definition of the required attributes of assets and information explaining what these attributes represent
- Definition of the criticality of assets
- A standardised approach to the assessment and recording of the condition
- A common approach for categorizing asset failures
- A defined approach to the assessment and recording of performance or serviceability
- Agreed methods for assessing and recording the utilization of an asset to determine its life and intervals between interventions

2.1.2. Planning and programming

Based on performance evaluation, improvements in value and service delivery can be planned. The result of this phase of the asset management approach is to provide a comprehensive asset management plan.

The planning phase starts with the definition, revision or confirmation of asset management policy. An asset management policy is a high-level document which provides a clear direction, defines principles and mandates requirements by which the organization manages its assets. It may, for example, define the organization's commitment to sustainable asset management practices or that the asset management plan and programme will be focused on minimizing the life cycle costs through proactive maintenance. It therefore provides a framework for translating the organization's strategic goals into asset management objectives and principles.

This framework allows the road asset manager to define an asset management strategy (strategic asset management plan – SAMP – also referred to as a transportation asset management plan – TAMP).

A SAMP or TAMP describes an organization's long-term approach to managing its assets. This specifies how organizational objectives are to be converted into asset management objectives, or the approach for developing the operational asset management plans. The SAMP may consist of:

- Definition of risk tolerability criteria
- Priorities for activities according to the criticality of assets
- A life cycle approach to particular types of assets, including maintenance strategies
  - Reactive maintenance strategy
  - Preventive maintenance strategy
  - Predictive/Proactive maintenance strategy
- Decision-making criteria
- Responsibilities for decision-making
- Information concerning the needs and expectations of stakeholders
- Future or expected asset functional and performance condition requirements
- Procedures for asset management plan approval, monitoring and revision
- Feedback from performance reviews

Figure 4
High level value chain of road authority

Source: ibid., Andrzej Maciejewski.

When developing an asset management strategy (SAMP, TAMP), it is important to take into account the current and forecast demand (traffic) for the organization's services and what impact this demand has on the requirements in terms of asset condition and performance. This demand analysis makes it possible to determine whether the current condition and its planned deterioration will be sufficient for the expected demand; if the performance will not be adequate, the analysis may support the decision-making process in determining the appropriate intervention (through maintenance or a capital project).

Having prepared the above documents and demand analysis, the road authority is able to carry out the process of optimization of the investment and maintenance decisions.

Capital investment decision-making comprises the process of evaluating and analysing options for the creation of new assets, increasing the capability of assets or the replacement of assets at the end of their useful life. An organization may have mandatory investments to comply with legal requirements or regulatory conditions. Other investments which may be considered discretionary have to be justified.

The most common method used for evaluating capital investment decisions is cost–benefit analysis (CBA) using discounted cash flows. The most common criteria used to compare alternative investments are net present value (NPV), internal rate of return (IRR) or payback period. The cost–benefit calculations should consider the required period of the asset's function and include lifetime expenditures and benefits, also known as life cycle costing.

The optimization of maintenance and operations is based – apart from the above-mentioned strategies – on failure modes analysis performed through, for example, failure mode and effects analysis (FMEA), documented standards for a particular road section's bearing capacity, deterioration models, technical standards for carrying out periodic and routine maintenance works on pavement and bridges, condition assessment and defined budget.

To combine all these factors and perspectives, the road asset manager should design a multi-objective optimization process based on a multi-objective decision analysis, complex mathematical algorithms to support the decision-making process.

These algorithms should be an essential part of the asset management information system architecture, which is the set of specific tools for data collection and management, performance evaluation, and improvements planning.

To appropriately prepare the operational asset management plan, the road asset manager should moreover assess the road authority's organizational capacity (for example in terms of competence of its employees, internal organizational procedures and other resources like technical equipment) to decide whether the execution of plans will be most effective and efficient using an in-house or outsourced basis. In asset management, this process is called resource strategy and management.

Finally, the asset management plan specifies the activities an organization plans to undertake to deliver its asset management objectives along with the resources required and ensured, the timescales and costs for completion, and the responsibilities for delivery. The information in an asset management plan includes:

- The responsibilities for leading and delivery of each activity
- The resources needed to deliver each activity including financial, human (skills, knowledge) and equipment (including the appropriate technical condition of equipment ensuring the reliability of works) as well as contractor information
- The timescales to complete activities
- Risks to delivery and mitigation measures

2.1.3. Works and services delivery

Eventually the road authority has to implement projects and activities defined in the plans and programmes, thus to procure relevant works from providers in the supply chain and to supervise them. This applies both to works related to the preparation of investments (including design and construction works) as well as to works related to the maintenance of the road network.

One of the main tasks of the road authority in this phase would be data collection related to the newly built assets. It is necessary to input data and information in the appropriate IT system to reflect any changes that occur during the construction phase in order to have enough information for the later life cycle management of the asset[7].

2.2. Linking of high-level processes and tools

2.2.1. Operational procedures

Having identified the common high-level processes, it is necessary to link them with relevant operational procedures and information systems (asset management tools). A comprehensive framework of operational procedures is illustrated in Table 2 (compare with Table 1).

[7] For details, please refer to the UNECE TEM Project report *Building Information Modelling (BIM) for road infrastructure: TEM requirements and recommendations*, to be published 2020.

Table 2
High-level processes and operational procedures of the road authority

High-level process	Operational Procedure
Performance evaluation	■ Assets technical condition assessment
	■ Deterioration forecasting
	■ Assets valuation/revaluation
	■ Traffic census
	■ Traffic forecasting
	■ Road safety inspections
	■ Road safety risk assessment
	■ Climate risk assessment
	■ Network criticality assessment and division into sub-networks (e.g., criticality due to road safety or climate risk due to physical resilience)
	■ Determination of maintenance strategies for particularly critical sub-networks
	■ Assets and network performance assessment including:
	■ Physical and functional failure likelihood and timing
	■ Capacity failure likelihood and timing versus demand forecast
	■ Economic failure likelihood and timing
	■ Determination of residual life of assets
	■ Determination of residual life of sub-networks (i.e., critical parts of the network)
	■ Determination of residual value
	■ Determination of life cycle and replacement costs
Planning and programming	■ Determination of possible treatments
	■ Treatments effectiveness evaluation
	■ Treatments cost evaluation
	■ Impact of works on network availability and reliability
	■ Impact of works on costs to the economy (social cost evaluation)
	■ Determination of possible treatment scenarios (capital/maintenance works)
	■ Application of determined maintenance strategies and scenarios selection
	■ Optimization and prioritization
	■ Elaboration of works programme
Works and services life-time	■ Preparatory works and designing
	■ Design data collection
	■ Asset construction
	■ As-built data collection
	■ Operations and routine maintenance of road network
	■ Periodic maintenance projects implementation
	■ Impact of data collection (traffic, road safety, technical condition)
	■ Projects delivery management
	■ Organization of day-to-day management
	■ Internal processes and management system data collection

Source: ibid., Andrzej Maciejewski.

According to the World Economic Forum's Industry Agenda, infrastructure is essential for sustained economic growth, competitiveness and social progress. While building new infrastructure assets ranks high on the global agenda, governments in both developed and developing countries often neglect their existing infrastructure assets. This leads to increasing congestion, unnecessary operational costs and inadequate maintenance.

Against the backdrop of increasing user demand, constrained financing and an ageing asset base, it is imperative for governments to make the most of their existing infrastructure assets – specifically, to increase the assets' productivity and longevity[8].

This challenge has been monetized by the McKinsey Global Institute (MGI). Their research shows that in the road sector alone investments need to be approximately $900 billion per year to keep pace with projected growth. Current investments in the road sector unfortunately fall short of this figure by $180 billion per year.

As was stated in the MGI and International Road Federation report on improving road delivery, a substantial part of the problem is that too many countries have, over long periods of time, paid insufficient attention to the maintenance of existing assets. As a result, large (and often increasing) maintenance backlogs occur. Congestion, deteriorating quality of roads and sometimes structural concerns lead to economically harmful closures. Clearing the maintenance backlog adds significant financial and capacity burdens to the already sizeable needs for new-build and ongoing maintenance.[9]

This context makes it necessary to focus the efforts of road authorities on planning for appropriate maintenance works and applying supporting tools which will enable these organizations not only to select projects on a data-driven basis but also to better obtain technical and financial support commensurate with an understanding of the potential for harm to the whole economy from insufficient funding of road network maintenance.

Keeping the above in mind, the following sub-sections of this report present systems whose main purpose is to improve, facilitate and automate road assets; evaluate the performance of road networks; and plan the delivery of services.

Improvement of the two phases described above will contribute the most to the overall capabilities of road authorities to compete for increased public spending.

The wider objective should be to demonstrate the importance of roads in underpinning economic development and the consequences of underfinancing, thereby making the case for appropriate levels of resource allocation from public funds[10].

2.2.2. Information needs and information systems

To succeed in achieving the outcome described above – when a road authority is capable of making data-driven decisions and becoming an active stakeholder competing for appropriate levels of funding for the road network's needs – it is vital to ensure that data are well managed and that information systems are integrated, complementing each other without creating unwanted overlap.

As presented in Table 2, there are several processes and procedures which require different types of information for the elaboration of multiannual and annual plans and programmes of works. Examples of the information needed are presented in Table 3[11]:

Table 3
Information needs for data-driven asset management

Information needed	Description
Asset inventory and design information	Includes location, type, quantity, material and design details (as-designed and as-built), pavement layers, bridge elements, asset valuation information.
Asset condition and performance information	Includes results of visual inspections, measured condition, performance measures (e.g., remaining service life), aggregated network level measures (e.g., the percentage of pavement in good/poor condition)[12].
Other asset information	Includes functional classification of the network, geometric characteristics, traffic volumes, congestion and reliability data, road safety data and information, geotechnical information, adjacent land uses, climate and weather data, natural environment data. The purpose of collecting this information is to help understand factors that may impact asset service requirements, goals, physical deterioration, funding eligibility or project needs and constraints.
Work information and treatment scenarios	Includes date, cost and scope of work required/proposed, scheduled and completed on the asset (all types of works from reconstruction, through rehabilitation and preservation, to maintenance).
Revenue and funding allocation	Includes historical and forecasted funds available for asset installation, reconstruction, rehabilitation, preservation and maintenance. Moreover, it includes historical allocations by asset category and work type.
Analysis information	Includes forecasted condition (deterioration) of assets and demand for the assets under varying scenarios (e.g., funding scenarios), treatment life, residual life, projects prioritization and/or optimization.

Source: ibid., American Association of State Highway and Transportation Officials (2020).

8 World Economic Forum, *Strategic Infrastructure: Steps to operate and maintain infrastructure efficiently and effectively* (Cologny/Geneva, April 2014).

9 Nicklas Garemo, Brendan Halleman and Martin Hjerpe, *A better road to the future: Improving the delivery of road infrastructure across the world* (n.p., McKinsey & Company, 2018).

10 See also the UNECE TEM Project *Business models for road sector/TEM Network: considerations and recommendations*, to be published 2020.

11 American Association of State Highway and Transportation Officials, *AASHTO Transportation Asset Management Guide*, 2nd ed. (Washington, D.C., 2020).

12 For more details regarding possible condition and performance information, it is possible to contact the TEM Project Central Office for a copy of the internal UNECE TEM Project report *Roads and motorways maintenance standards* (2019).

Road authorities store and manage needed information and data using several different information systems, examples of which are presented in Table 4 below. Both the amount of required information and variety of available information systems and applications may be confusing, especially for high-level decision makers or executives. Specialists, understanding their area of interest in greater detail, know what information and what information systems they need.

Table 4
Types of information systems used by road authorities

Information system	Description
Data warehouse and business intelligence systems	Used to integrate data from different sources and sub-systems for feeding analytical models and for reporting.
Enterprise geographic information systems	Used to manage spatial information, including asset location. Depending on the particular needs, assets may be presented as point, linear or polygon features. Location may be specified based on coordinates or based on a linear referencing system (LRS). Asset features maintained within GIS may be linked to asset information within other systems.
Maintenance management systems	Used to plan and track routine maintenance activities; typically store information about planned and completed maintenance activities and resources consumed. May also include customer work requests, work orders and maintenance level of service.
Programme and project management systems	Used to manage information about capital and major maintenance projects from initial planning and programming through completion. There may be separate systems for managing programming/funding information, design information and construction phase information (depending on the implementation model and maturity in terms of architectural approach for systems implementation).
Enterprise resource planning system (ERP, including financial management systems)	Used to manage and track revenues, expenditures, budgets, grants, payments, receipts and other financial information. These systems may support budgeting and/or revenue forecasting and analysis. Moreover, these systems cover a wide variety of other modules for functions including HR, premises, fleet, project programming and management.
Road safety data systems	Used to store and report data about collisions and resulting injuries and fatalities, road safety risk assessment and mapping from cyclical road safety inspections and audits.
Traffic monitoring systems	Used to store and report traffic data, required for different types of reporting and contributing to demand analysis and asset deterioration modelling, treatment selection and prioritization.
Imagery databases	Used to store video imagery and mobile LiDAR data that can be used for manual or semi-automated extraction of asset inventory.

Source: ibid., American Association of State Highway and Transportation Officials (2020).

Considering the costs in time and money of implementing asset management information systems, a clearer understanding of the information needs and possible information systems is illustrated by the matrix in Table 5:

Table 5
Matrix of information needs and alignment with IT systems

	Asset inventory and design information	Asset condition and performance information	Other asset information	Work information and treatment scenarios	Revenue and funding allocation	Analysis information
Data warehouse and business intelligence	X	X	X	X	X	
Enterprise GIS	X	X	X	X		
Maintenance management system		X		X		X
Programme and project management system				X	X	
ERP and financial system	X			X	X	
Road safety data system			X			X
Traffic monitoring system			X			X
Imagery database			X			

Source: ibid., American Association of State Highway and Transportation Officials (2020).

As shown above there is no one type of information system, module or application that will cover all the information needs of a road authority. Certainly, there are many vendors or IT system integrators who offer comprehensive solutions, combining specific attributes of the presented information systems; however, they usually require detailed and time-consuming adjustment to the needs of a particular road authority.

This requires the road authority possess strong competencies and a detailed awareness of its information needs to ensure the authority doesn't simply purchase a system that a particular provider has on offer. Choices should be made with careful consideration of the agency's current application portfolio, technology environment and staff resources.

Implementation of advanced analytical capabilities and tight integration across information systems can pay off, but this requires considerable commitment. Many agencies that implement sophisticated asset management systems later fail to make full use of their new capabilities due to the limitations of their underlying business needs, internal resource constraints and the time, effort and data required to build credible models that can be used for decision support.

2.2.3. Asset management information systems implementation models

International practice suggests the above-mentioned concerns may be addressed by adopting an architectural approach to the implementation of asset management information systems.

Starting with a big picture view of how asset management information systems will be structured and interfaced with the organization's existing and planned business systems is always helpful.

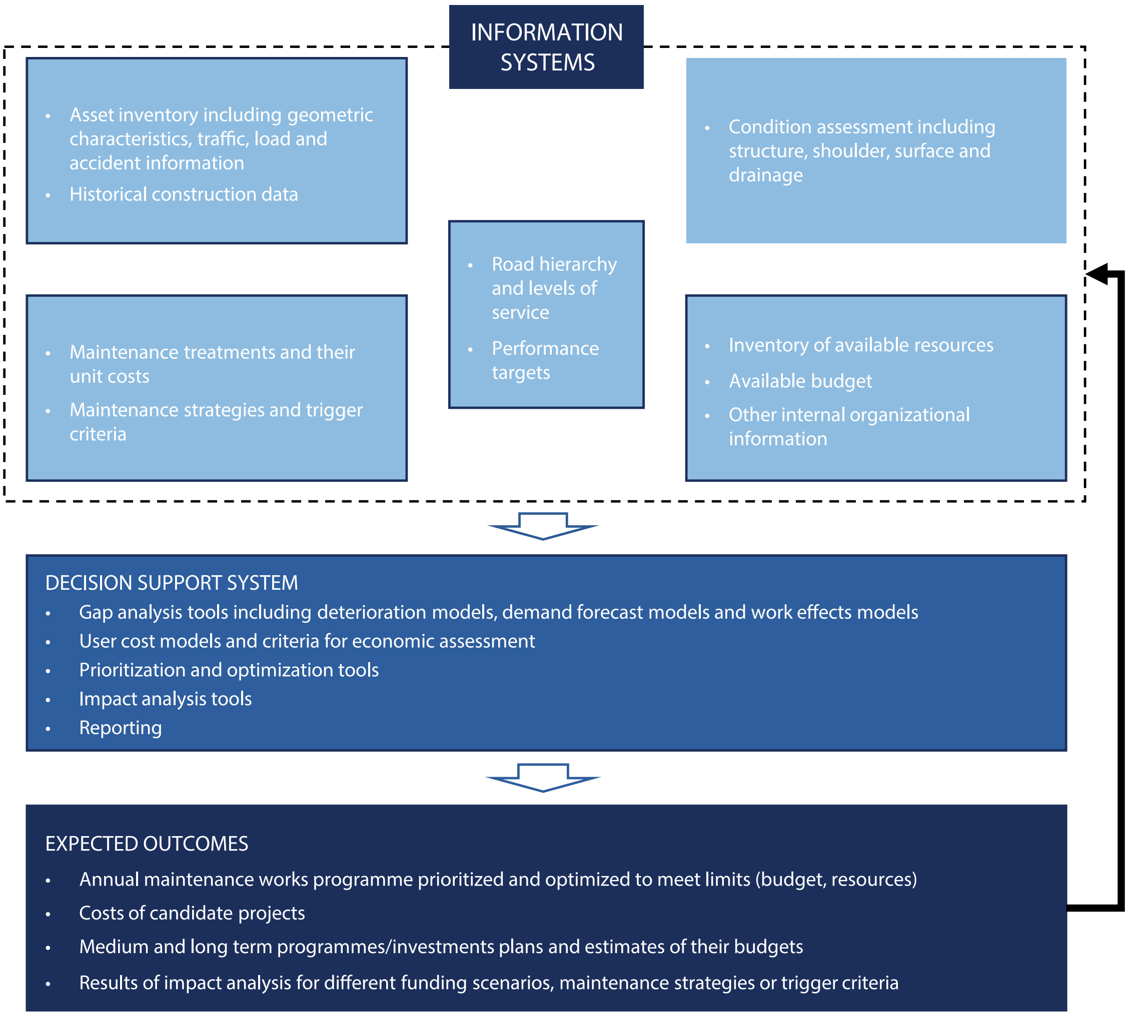
Without this kind of planning, reliance on a purely incremental, bottom-up approach to implementing asset management tools can result in duplicative functionality, lack of integration across data sets and inconsistent processes across asset categories.

This leads to higher costs to the road authority for hardware, software and labour to maintain and operate multiple systems and multiple interfaces across systems. It can also create significant barriers to the effective use of information.

In general, it is more cost-effective to consolidate similar types of functionality and use a modular approach to system implementation. However, organizations rarely have the opportunity to start with a clean slate – they must work with a collection of legacy systems of different vintages.

In addition, sometimes the desire to utilize top-rated solutions for particular assets and to avoid being contractually tied to a single vendor (vendor lock-in) provides a justification for applying multiple systems that possess overlapping functionality.

Figure 5
Relations of information needs and information systems



Source: Austroads, Guide to Asset Management, 3rd ed., July 2018.

Nevertheless, an architectural vision that identifies common building blocks and their interfaces provides an essential blueprint for guiding asset management system investments.

Based on Australian, New Zealand and United States experiences[13], there are three common approaches to the implementation of asset management systems as shown in the following models.

Model 1

A single, integrated system (acquired commercially or custom developed) stores and manages information about multiple assets, includes both geospatial and business attributes in its database, and supports multiple asset management business functions:

- Inspections
- Maintenance
- Rehabilitation planning
- Work scheduling and management

Such systems are usually modular to allow for incremental development by adding new assets (vertical improvement, e.g., adding bridges to roadways) or new processes (horizontal improvement, e.g., adding optimization and support for capital investments to the maintenance planning) over time.

This model is recommended when a road authority is responsible for a relatively small network, is starting from scratch or is undertaking a complete replacement of existing systems.

Model 2

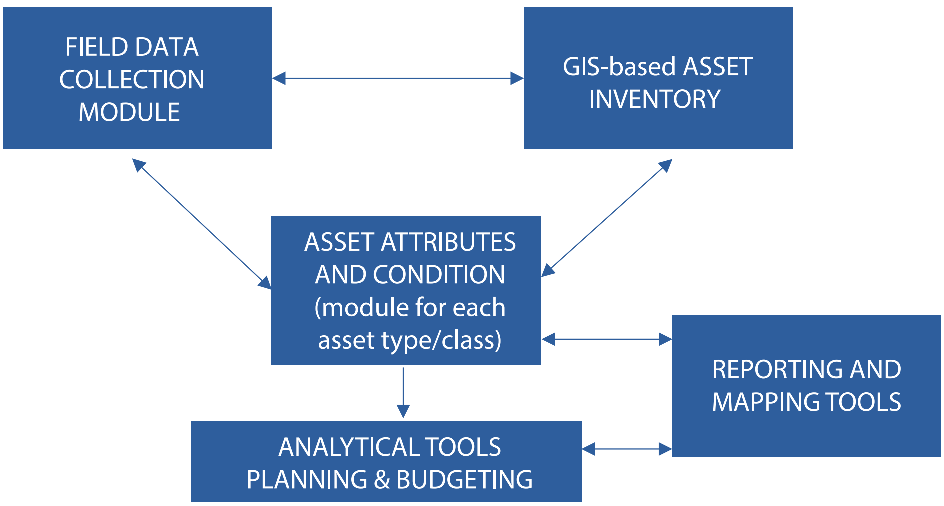
This model consists of individual data and analysis systems feeding an integrated asset management planning tool. Model 2 may be used when a road authority wishes to build upon existing legacy systems but also to provide an integrated planning capability (with regard to processes, procedures and systems architecture).

As a hybrid or hierarchical variation on Model 2, a road authority may also have separate, full-fledged management systems for asset categories where commercial off-the-shelf systems are available (e.g., paved roads and bridges) and a simple, home-grown database for all other categories of assets. The authority can also have more sophisticated systems delivered in-house, depending on the internal capacity of a particular road authority or the business decisions of the executives regarding just how independent from vendor lock-in risk they want to be.

The separate management systems handle the generation of alternatives, forecasting, maintenance planning, and optimization of policies and specialized programmes within asset categories (e.g., a bridge painting programme or pavement overlay programme).

To complete the hybrid framework, a commercial or home-grown trade-off analysis may provide the integrating linkage among the separate systems to support planning, programming and budgeting of business processes that integrate all asset categories. The integration component would support resource allocation among the activity categories and programmes addressed by the lower-level management systems.

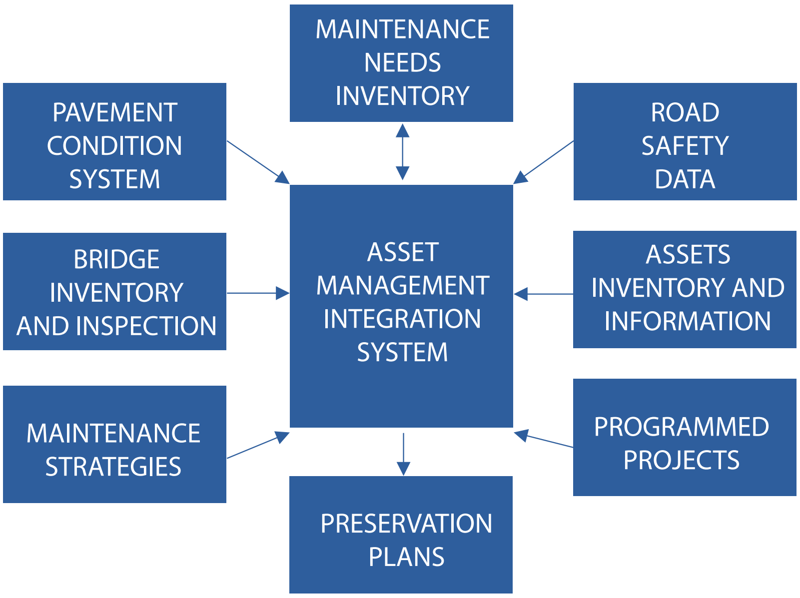
Figure 6
Fully integrated asset management information system (Model 1)



Source: American Association of State Highway and Transportation Officials, AASHTO Transportation Asset Management Guide (Washington, D.C., 2011).

[13] Ibid., Austroads.

Figure 7
Asset management system integrating separate modules (Model 2)



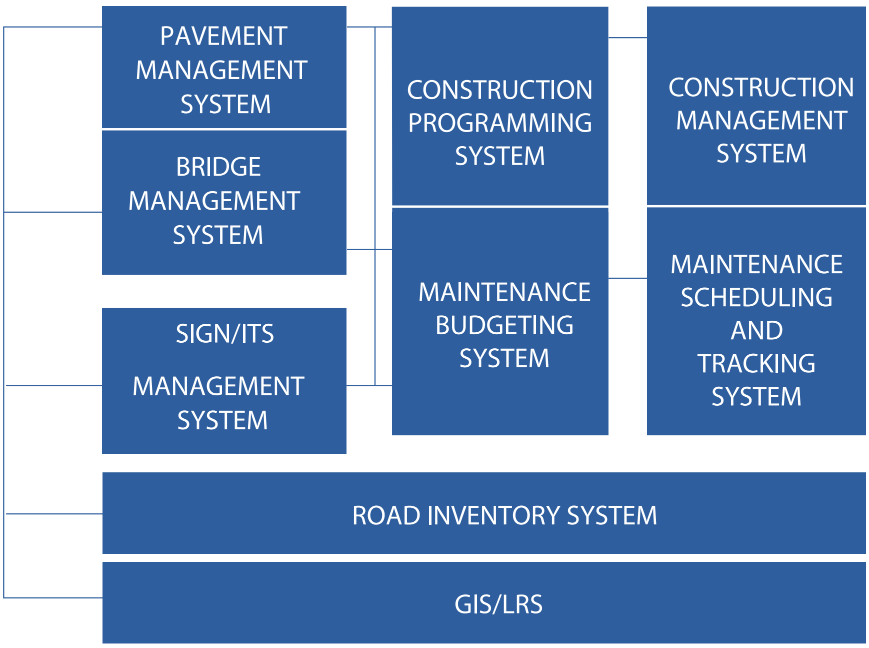
Source: ibid., American Association of State Highway and Transportation Officials (2011).

Model 3

The third model features separate, specialized, self-contained systems for paved roads, bridges and other selected assets (e.g., signs, culverts, signals, ITS equipment) with interfaces to budgeting and management systems for maintenance and construction.

Interfaces to the road authority asset inventory and linear referencing system management tools may also be included as presented below.

Figure 8
Separate management systems with interfaces (Model 3)

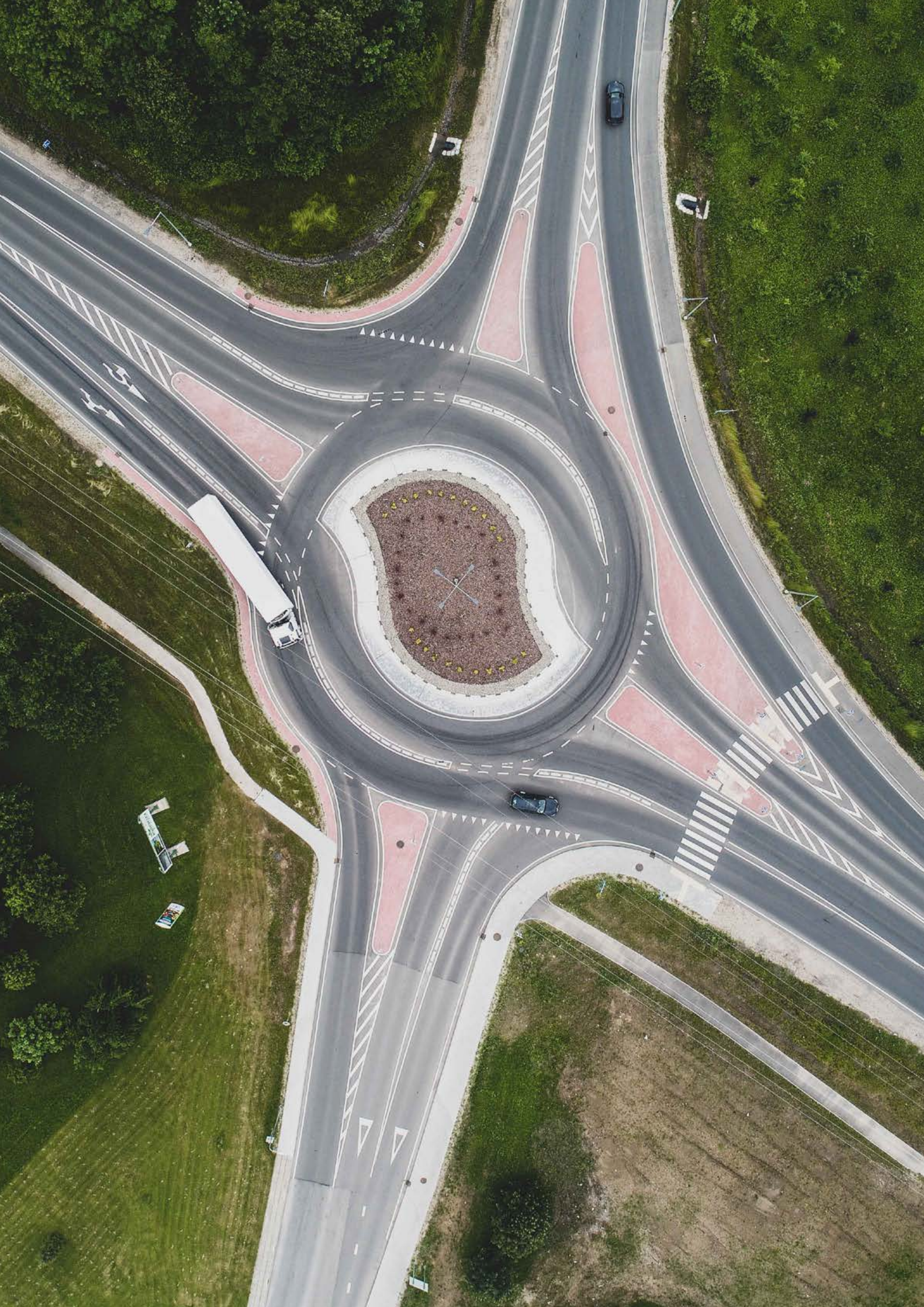


Source: ibid., American Association of State Highway and Transportation Officials (2011).

Any of these approaches, or a combination, may be successfully applied. Decisions should be made based on initial and ongoing costs, risks, future adaptability, and compatibility with established information technology architecture and the current systems portfolio.

Key trade-offs to consider in deciding on which model to use include:

- Ability to utilize top-rated solutions where a high degree of specialization is required versus the ability to simplify implementation and maintenance by using a standardized approach for multiple assets
- Lower cost and reduced complexity of implementing a fully integrated system out-of-the-box versus the ability to utilize the organization's existing tools and integrate with the organization's data
- Simplicity and ease of relying on a single external vendor for support and enhancements versus the reduced risk of vendor lock-in associated with a multi-vendor or in-house development approach



Section 3: Description of asset management tools

This section provides detailed information about particular tools which, from the perspective of the current analysis, are the most relevant for implementation regardless of the model selected (see 2.2.3). If an organization decides to take the approach in Model 2 (separate implementation of particular modules), then it is necessary to understand how the modules are interrelated so that needed modules and analysis are not missing in certain management processes.

If the organization decides to take the approach of comprehensive system implementation using an external vendor, the organization should be adequately aware of the detailed requirements for the various parts of the systems provided, purchasing only what is necessary or required per the terms of reference.

It is important to bear in mind that information systems should be treated as the automation of existing procedures. For that reason, the description of asset management tools starts from operational procedures.

It is critical to consider a comprehensive asset management tools matrix. In the IT system development process – usually the very first step of asset management maturity building (mistakenly treated as a silver bullet at the initial stage) – hardware, software, data, processes and people (competencies) must be taken into consideration. Sometimes too much focus is placed on one aspect over another, resulting in – for instance – a software system that is overly complex for the people who will be using it.

Moreover, asset management information systems should fall under the umbrella of the general IT architecture of the various systems the organization possesses and develops, so as not to duplicate data collection processes (causing additional costs to the organization) or to eliminate at times dangerous gaps in information between systems that have been deployed separately.

3.1. Performance management framework

All internal operational procedures must create a comprehensive system of steps and actions allowing an organization to deliver the expected value (outcomes) for customers.

To achieve this, road authorities should define and decide upon an overall performance management framework which will enable the following:

- Allow the management to see the big picture with an appropriate level of detail
- Help the employees to understand how their operational activities contribute to the general outcomes expected from the organization
- Permit both these groups to measure whether the results are sufficient and how to improve outcomes in the future

Adopting a performance management framework allows the implementation of performance-based decision-making, which is one of the core principles of asset management (see Figure 1). A road authority must be able to demonstrate that they are making progress on the established goals and objectives. The authority must be able to set goals and objectives tied to measurable metrics, to make resource allocation decisions based on these goals and the funding available (using the metrics to guide decision-making), and then to demonstrate to stakeholders the results of the investments.

The role of performance measurement as a critical aspect of public sector activity is captured by David Osborne in his study titled "Reinventing Government"[14].

He describes why performance management and measurement is important with the following points:

- What gets measured gets done
- If you do not measure results, you cannot tell success from failure
- If you cannot see success, you cannot reward it
- If you cannot see success, you cannot learn from it
- If you cannot reward success, you are probably rewarding failure
- If you cannot recognize failure, you cannot correct it
- If you can demonstrate results, you can win public support

[14] David Osborne, "Reinventing Government: what a difference strategy makes", 7th Global Forum on Reinventing Government: Building Trust in Government, Vienna, 26-29 June 2007.

The establishment of a performance management approach will help a road authority to demonstrate responsiveness to customer needs, provide accountability for budget expenditures and ensure satisfactory levels of service or results.

Each road authority must review its current processes, identify performance measures and implement these measures in a performance management framework that includes performance targets and monitors agency progress towards these targets. Where appropriate, the performance measures will be comparable among regions, districts and the organization (road authority) collectively.

Implementation of performance-based management is an iterative process. In the first stage, the road authority might not have clear metrics to relate its delivery activities to changes in outcomes experienced by customers. It may need to rely on expert judgment for forecasting and trend analysis for setting targets. The interaction of setting targets and programming might rely heavily on guesswork.

Continuous improvement means executives are not satisfied with the current state of management. Each cycle should therefore feature an evaluation of lessons learned and improvement in delivery, measurement and forecasting capabilities.

As road authorities mature, they rely more on quantitative information to update their targets and develop their programmes. They use quantitative priority setting based on performance measures, becoming more responsive to policymakers in terms of the ability to adjust targets and programmes together in response to the funding environment and public concerns. Executives gain more confidence that they can achieve targets and be accountable for them.

There are a few examples of performance management frameworks, but two of them may be described in greater detail in the following sub-sections as the most comprehensive and most popular.

3.1.1. Balanced scorecard

In 1992, Robert S. Kaplan and David P. Norton introduced the balanced scorecard, a set of measures that allow for a holistic, integrated view of business performance. The scorecard was originally created to supplement "traditional financial measures with criteria that measured performance from three additional perspectives – those of customers, internal business processes, and learning and growth"[15].

By 1996, companies using the scorecard had further developed this approach as a strategic management system linking long-term strategy to short-term targets. The development of the balanced scorecard method occurred because many business organizations realized that focus on a one-dimensional measure of performance (such as return on investment or increased profit) was inadequate.

Too often, bad strategic decisions were made in an effort to increase the bottom line at the expense of other organizational goals. The theory of the balanced scorecard suggested that financial performance, rather than the focus, is the natural outcome of balancing other important goals.

These other organizational goals interact to support excellent overall organizational performance. If any individual goal is out of balance with other goals, the performance of the organization as a whole will suffer.

The balanced scorecard system also emphasizes articulation of strategic targets in support of goals. In addition, measurement systems are developed to provide data necessary to know when targets are being achieved or when performance is out of balance or being negatively affected.

The Kaplan and Norton balanced scorecard looks at a company from four perspectives:

- Financial – How do we look to shareholders?
- Internal business processes – What must we excel at?
- Innovation and learning – Can we continue to improve and create value?
- Customer – How do customers see us?

By viewing the organization from all four perspectives, the balanced scorecard provides a more comprehensive understanding of current performance. While these perspectives are not completely inappropriate for use by public authorities, it is possible to adapt the balanced scorecard theory using a paradigm more traditional to the delivery of services in the public sector.

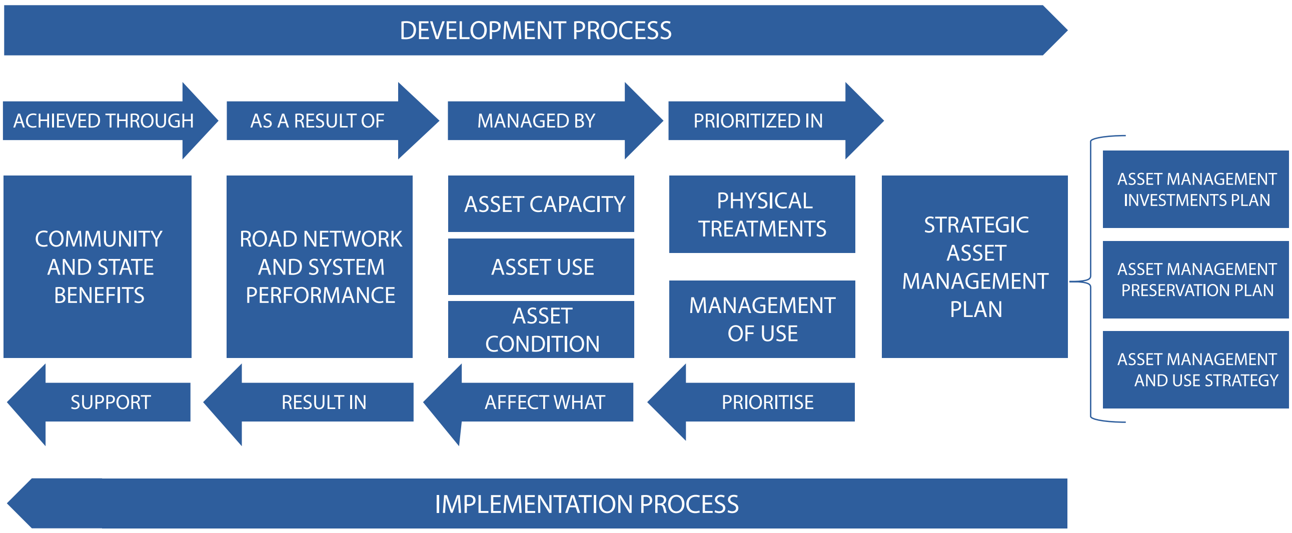
Figure 3 already showed how to apply the balanced scorecard to a road authority. Adopting a top-down approach, road authorities need to understand the economic and financial context of their operation, as road infrastructure usually places a substantial burden on public finances.

Additionally, a national road authority is responsible and accountable for the management of the road system to ensure an acceptable, affordable and sustainable level of services and a level of performance appropriate to the road users and the community.

The optimum performance of the road system is achieved through the integrated management of the capacity, condition and use of the road infrastructure assets, a combination of physical treatments (construction and maintenance) to manage and maintain the asset together with operational measures to manage how the road system is used so that road users and the general community have access to the road network.

[15] Robert S. Kaplan and David P. Norton, *The Balanced Scorecard: Translating Strategy into Action* (Harvard Business Review Press, 1996).

Figure 9
Linking of strategic goals, operational objectives and technical standards



Source: ibid., Andrzej Maciejewski.

Road asset management has its key elements in a defined hierarchy that provides an appropriate sequence to the overall development and implementation of strategy. This set of key road asset management elements starts with the community or state benefits, which are achieved through the road system's performance level.

The road system performance level is the result of asset capacity, use and condition achieved by defined physical treatments and management of use. Physical treatments and management of use are prioritized and concluded in the asset management strategies as a basis for planning and programming of road network maintenance and development.

Conversely, asset management strategies target and prioritize physical treatments and management of use to affect the attributes of asset capacity, use and condition. This results in the desired road system performance to support the achievement of community and state benefits.

The balanced scorecard would help to structure the abovementioned requirements, needs and expectations into a clear strategy map. Such a strategy map – through the uniqueness of the business scorecard approach – will show what economic and financial outcomes the road authority should achieve (regarding both cost reduction and revenue increase) and how these economic outcomes are tied with levels of services the road authority is obliged to provide to customers and stakeholders.

Furthermore, by applying appropriate technical measures – used as lead measures (targets) and lag measures (key performance indicators) – for each service, the road authority will be able to appropriately organize its internal business processes into a logical value chain.

Finally, to be able to carry out processes reflected in the value chain, the road authority should adjust its procedures, systems and competencies.

All four of these perspectives are interrelated, and these relationships are reflected through the performance evaluation framework, thus comprising a set of performance measures to assess the level of service delivery, asset performance and the organization's performance.

3.1.2. 7S model

The McKinsey 7S Framework is a management model developed by the business consultants Robert H. Waterman, Jr. and Tom Peters in the 1980s.

This model is a strategic vision that includes businesses, business units and teams. The seven Ss are as follows:

- Structure
- Strategy
- Systems
- Skills
- Style
- Staff
- Shared values

The model is most often used as an organizational analysis tool to assess and monitor changes in the internal situation of an organization.

The model is based on the theory that, for an organization to perform well, these seven elements need to be aligned and mutually reinforcing. Thus, the model can be used to help identify what needs to be realigned to improve performance or to maintain alignment (and performance) during other types of change[16].

Whatever the type of change – restructuring, new processes, organizational merger, new systems, change of leadership and so on – the model can be used to understand how the organizational elements are interrelated and therefore ensure that the impact of changes made in one area is considered in a wider context.

The main objective of this model is to:

- Improve the performance of an organization
- Examine the likely effects of future changes within an organization
- Align units and processes during a merger or acquisition
- Determine how best to implement a proposed strategy

The above seven elements can be divided into two main groups as seen in the table below.

Table 6
7S McKinsey model for performance management

Hard	Soft
Strategy	Shared values
Structure	Skills
Systems	Staff
	Style

Source: ibid., Andrzej Maciejewski.

The three hard elements are strategy, structures (such as organization charts and reporting lines) and systems (such as formal processes and IT systems). These are relatively easy to identify, and management can influence them directly.

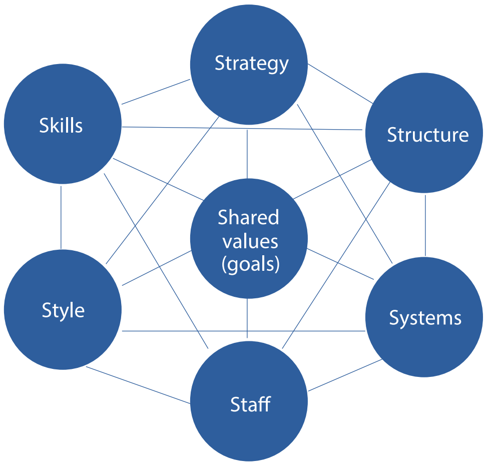
The four soft elements, on the other hand, can be more difficult to describe, less tangible and more influenced by an organization's culture. Nevertheless, they are just as important as the hard elements if the organization is to be successful.

- Strategy – This is how an organization plans for building and maintaining its advantage over its competitors. This is also applicable for public sector organizations which, as stated earlier, must compete for public funds using a more informed approach to the services they are responsible for.
- Structure – This is how an organization is organized (how departments and teams are structured, including who reports to whom).
- Systems – These are the daily activities and procedures that staff undertake to get the job done.
- Shared values – These are the core values of the organization as shown in its culture and general work ethic. They were called superordinate goals when the model was first developed.
- Style – This is the style of leadership adopted.
- Staff – These are the employees and their general capabilities.
- Skills – These are the actual skills and competencies of the organization's employees.

This approach to a performance management framework sets shared values at the centre of focus to emphasize that these values are key to the development of all the other critical elements.

The model states that the seven elements need to balance and reinforce each other for an organization to perform well.

Figure 10
McKinsey 7S model for performance management



Source: ibid., Andrzej Maciejewski.

An organization may use this model to identify which elements it needs to realign to improve performance or to maintain alignment and performance during other changes. These changes could include restructuring, new processes, an organizational merger, implementation of new systems or a change of leadership.

As with every tool, the 7S model is a good framework to help the organization ask the right questions, but it won't provide all the answers. It is thus necessary to bring together the right people with the right knowledge, skills and experience. Regardless, this methodology provides a high-level checklist to get started.

The following questions are a starting point for exploring an organization's readiness to apply the 7S Framework. They allow an organization to first find its current (Point A) situation and then repeat the exercise for the proposed situation (Point B).

16 Compare with 1.3

Table 7
Checklist questions for 7S model

Model element	Checklist questions
Strategy	■ What is our strategy? ■ How do we intend to achieve our objectives? ■ How do we deal with competitive pressure? ■ How are changes in customer demands dealt with? ■ How is strategy adjusted for environmental issues?
Structure	■ How is the organization/team divided? ■ What is the hierarchy? ■ How do the various departments coordinate activities? ■ How do the team members organize and align themselves? ■ Is decision-making and controlling centralized or decentralized? Is this as it should be, given what we're doing? ■ Where are the lines of communication? Explicit and implicit?
Systems	■ What are the main systems that run the organization? Consider financial and HR systems as well as communications and document storage. ■ Where are the controls and how are they monitored and evaluated? ■ What internal rules and processes does the team use to keep on track?
Shared Values	■ What are the core values? ■ What is the organization/team culture? ■ How strong are the values? ■ What are the fundamental values that the organization/team was built on?
Style	■ How participative is the management/leadership style? ■ How effective is that leadership? ■ Do employees/team members tend to be competitive or cooperative? ■ Are there real teams functioning within the organization or are they just nominal groups?
Staff	■ What positions or specializations are represented within the team? ■ What positions need to be filled? ■ Are there gaps in required competencies?
Skills	■ What are the strongest skills represented within the organization/team? ■ Are there any skills gaps? ■ What is the organization/team known for doing well? ■ Do the current employees/team members have the ability to do the job? ■ How are skills monitored and assessed?

Source: ibid., Andrzej Maciejewski.

3.2. Performance measurement framework

Regardless of the selected performance management framework (as discussed in another TEM Project report on business models for the road sector[17]), it is the responsibility of road asset managers to respond in an effective way to budgetary constraints. It is therefore necessary not only to apply for additional funding but also to understand how the road authority can decrease its appetite for funds through increased efficiency and effectiveness.

To achieve this, road authorities should apply comprehensive content to the selected management framework. Such content would comprise selected performance measures that reflect the given goals and objectives.

The ability to apply and refine delivery and forecasting capabilities requires a hierarchy of performance measures.

Certain measures, at the highest levels, correspond to the qualities of service provided to the public. Other measures, more detailed and technical, help the agency to manage its internal processes in a manner that leads to accomplishment of the larger objectives.

As the road authority matures, its systems and research enable it to link performance at each level of the organization to tell, for example, what values of project level productivity are required in order to deliver an increase in network-level condition to a targeted level.

[17] Ibid., *Business models for road sector/TEM Network: considerations and recommendations*.

According to a National Cooperative Highway Research Program report[18], the performance measurement framework should consist of:

- Performance measures which translate policy objectives into guidance for the decision-making process – If, for instance, the goal is to ensure an appropriate level of resilience of the road network to growing demand from heavy vehicles, the road authorities should reflect this expectation in appropriate technical performance measure like the number of kilometres of roads with reinforced construction.
- A framework to optimize the mix of possible investments (operations, periodic maintenance, reconstruction) – The road authority should adopt appropriate thresholds which, depending on the current and forecast technical condition, will allow or not allow the use of particular maintenance scenarios (for example, if the road section is heavily deteriorated the thresholds cannot allow only light repairs, while if the road has not deteriorated the thresholds should allow for light repairs that prevent the network from deteriorating).

Moreover the measurement framework should help in the following:

- It should define expectations and outcomes for budget decisions. Having the two abovementioned steps in place, the road authority can prepare with greater precision its multiannual plan and both mid-term and short-term programmes, defining the need for resource allocation (e.g., financial resources).
- The framework should track the effectiveness of programme and service delivery. Performance measures in their lead form will support the decision-making process. In their lag form, the measures would inform the road authority about what has been achieved in order to compare with earlier assumptions and to plan any necessary improvements, both in programme and service delivery and in system conditions and service levels.

Road authorities should differentiate between output and outcome measures or targets. An output is the quantity of work performed by the agency, such as the number of lane kilometres paved or signs replaced. Outcomes, on the other hand, are the resulting improvements in performance or condition in areas directly relevant to the public, such as condition, cost, mobility, access, safety, reliability, comfort, convenience, externalities and risks.

Including output measures in combination with outcome measures may provide the best support to the overall asset management process because:

- Outputs are easier and less expensive to measure and are therefore good for quantifying interim results before outcomes can readily be measured
- Outputs provide a tangible indication of accomplishment
- Outcomes are directly related to the agency mission and directly relevant to the needs of stakeholders
- Outcomes are directly comparable with the cost drivers that prompted the agency to take action, e.g., the before and after condition of a section of pavement
- Output may be correlated to outcome through research, providing a measure of effectiveness of agency activities

An effective approach to kickstart and perpetuate asset management implementation from the top is to report basic outcome and output performance measures on the agency's website in the form of an annual report or an interactive web page. The presentation of the data should show how the measures have changed over time and how they vary among parts of the state or jurisdiction.

To capture a full road-authority-wide perspective on performance measurement, it is necessary to develop a framework such as that provided, for instance, by the National Cooperative Highway Research Program (as above).

Good asset management requires that the right information be available at the right levels of the agency at the right time. For each decision maker, the goal of performance measurement is to be presented with information specific to the role, shaping the understanding of current performance and the effects of prospective decisions on future performance.

Effective asset management naturally requires knowledge of the assets being managed. The quality of project selection, trade-off analysis and resource allocation decisions are directly related to the quality of the information upon which those decisions are based. Quality asset data are also a key input to a quality asset management plan. Since data collection can be a significant asset management cost, it is only prudent to cast a critical eye on the cost and value of data gathering processes.

[18] Transportation Research Board of the National Academies, *NCHRP Report 551: Performance Measures and Targets for Transportation Asset Management*, National Cooperative Highway Research Program (Washington, D.C., 2006).

A typical list of these measures could be[19]:

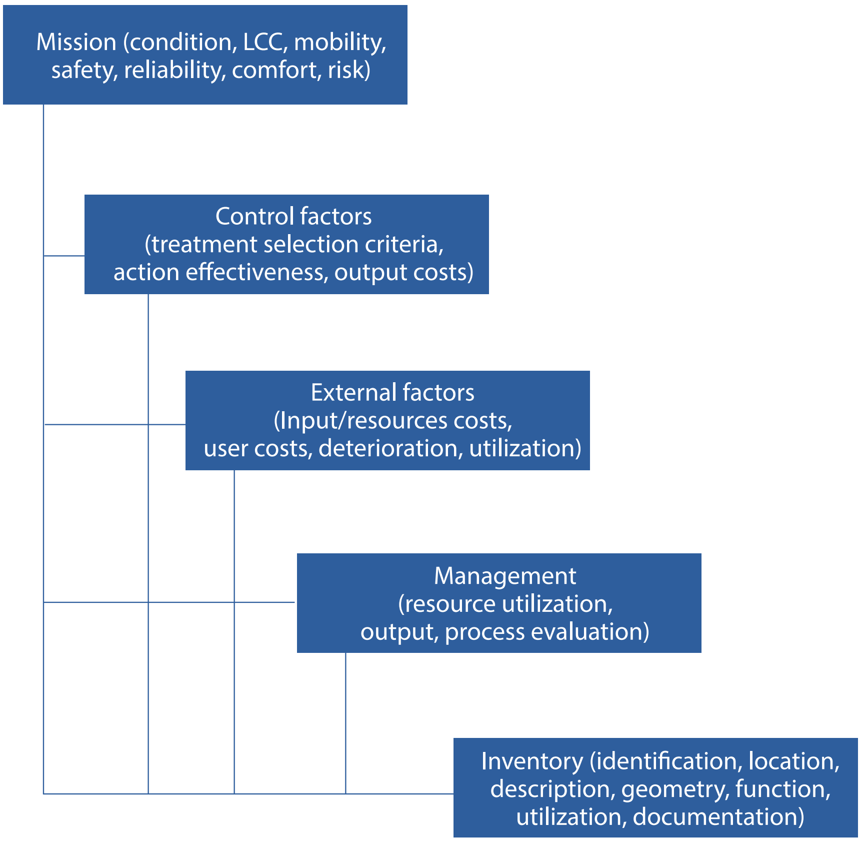
- Condition – a generic condition scale that applies to all types of assets, reflecting the effect of asset condition on the public. This is typically built from physical condition measures but is a customer-focused representation.
- Life cycle cost – the weighted sum (usually discounted net present value or equivalent uniform annual cost) of near-term and longer-term expenditures, reflecting the trade-off inherent in the timing of investments and the long-term responsibility to taxpayers.
- Safety – a measure of the likelihood of being injured or killed, or experiencing property damage, when using the transportation system.
- Mobility – a measure of how long it takes, on average, to travel from origin to destination, considering link availability, obstructions, congestion, etc.
- Accessibility – the ability of landowners to reach their land and travellers to reach their destinations on the public road or transportation network.
- Reliability – quantifies the variation in origin–destination trip times due to congestion and incidents.
- Comfort or convenience – measures the subjective experience of transportation system users.
- Externalities – the effect of the transportation system on non-users and the environment.
- Risk – the impact of extreme events, including their likelihoods, their effects on the facilities and the effects of facility damage on the public.

A road authority may have one or more condition or performance measures in each category. When using the measures to communicate with external stakeholders and the public, it is best to keep the list short and related to the agency's high-level values. This is because of the importance of simplicity and clarity in communicating with laypersons. A longer list may be useful to senior management when diagnosing problems and allocating resources.

Relations between collected data and their usage for the performance measurement can be depicted as in Figure 11 taken from the AASHTO *Transportation Asset Management Guide*.

[19] Ibid., AASHTO.

Figure 11
Performance measurement and data requirements.



Source: ibid., American Association of State Highway and Transportation Officials (2011).

3.3. Growth and demand management [20]

Having established what the agreed levels of service are, providing them for current customers is a matter of prioritization and resource allocation. However, providing the agreed levels of service for future customers requires knowledge of who they may be and their likely needs.

This requires consideration of the likely effects of changes in population (growth or decline), changes in land use (e.g., agricultural to residential) and changes in consumption patterns (e.g., changes in automobile usage). The end results are changes in the number or size, or both, of the road authority's assets and facilities or the levels of service it delivers.

Long-range transportation planning is a key input not only into the road authority's forecasts but also into the growth and economic forecasts of the state and municipalities. The necessity to provide the required levels of service in the most cost-effective manner leads to consideration of the options available for addressing likely increases in demand – beyond the conventional option to build greater capacity, instead considering a reduction in the need or demand for the particular asset.

Transportation demand is a function of land use and the spatial interaction between land uses. Fundamentally, congestion is the failure to reconcile demand (caused by land use and spatial interactions) and acute supply constraints (the transportation network).

As such, land use is one of the largest determinants of transportation demand. Land use represents a level of spatial accrual from which transportation demand is derived.

There are many spatial economic models that can be used to estimate transportation demand, mainly through the generation and attraction of traffic by different land use zones. Transportation and land use that is planned together can yield not only more liveable communities but can also improve the quality of life of motorists by reducing transportation demand and congestion.

Transportation and land use planning processes rely on assessments of population change (growth or decline), while other factors impact transportation demand, such as land-use changes, commercial and industrial development, traffic patterns, the cost of travel and the state of the economy.

The needs identified by asset management and strategic planning are also sensitive to future projections, so consistency in growth assumptions across the agency is essential. Pavement and bridge management databases frequently have facility-level growth forecasts that must be consistent with long-range plans.

Metropolitan and central level transportation plans are cooperative efforts among multiple agencies, producing growth projections and strategic decisions about how growth will be managed and accommodated. Periodic review is required in order to ensure that asset management assumptions remain consistent with the agency's perception of its future strategic environment. Good asset management practice reflects the land use policies of state, county and municipal authorities in both data and forecasting processes.

In addition to growth and strategic posture, demand for transportation services is also affected by:

- Changes in legislation
- Changes in technology
- Changes in asset utilization such as truck weights
- Changes in the cost of energy
- Charging for road use through tolling, congestion pricing, etc.
- Changes in attitude towards the use of alternative modes of transport, such as increasing use of transit systems
- Seasonal changes in use, e.g., access for skiing, hunting, fishing, hiking or water-based recreation
- Changes in customer expectations, such as the "complete streets" movement that has led to increased demand for pedestrian and bicycle facilities
- Changes in socio-economic factors including age, employment and income

All these factors should be taken into consideration through prognostic models to provide enough data to feed information systems used by the road authorities to plan road network development.

3.4. Risk management

Risk management is a process of identifying sources of risk, evaluating them, and integrating mitigation actions and strategies into the routine business functions of the agency.

Risk is associated with uncertainty. Risk management should be viewed as a core business driver influencing all activity and not as an isolated, add-on process.

Integration of risk management into asset management is relatively new, focusing thus far on bridges and tunnels. However, all types of transportation assets have uncertainty and risk factors associated with them.

[20] Ibid., AASHTO.

It must be remembered that the risks associated with individual assets translate immediately into risks for the agency, and the consequences and effects of all risk events must therefore be considered at the agency level too.

Risk in asset management is commonly assessed as vulnerability to a variety of natural and manmade hazards. This assessment is typically conducted in three steps:

- Likelihood of an extreme event – expressed as a probability, or range of probabilities, of an event such as a flood, earthquake, asset failure or other risk driver
- Consequences to the asset – a categorization of the damage or loss of function of the asset, conditional on the occurrence of an event
- Effect on mission, life, property and the environment – a categorization of the effect on the agency, the public, users and non-users of the asset, as well as damage or loss of function caused by the extreme event

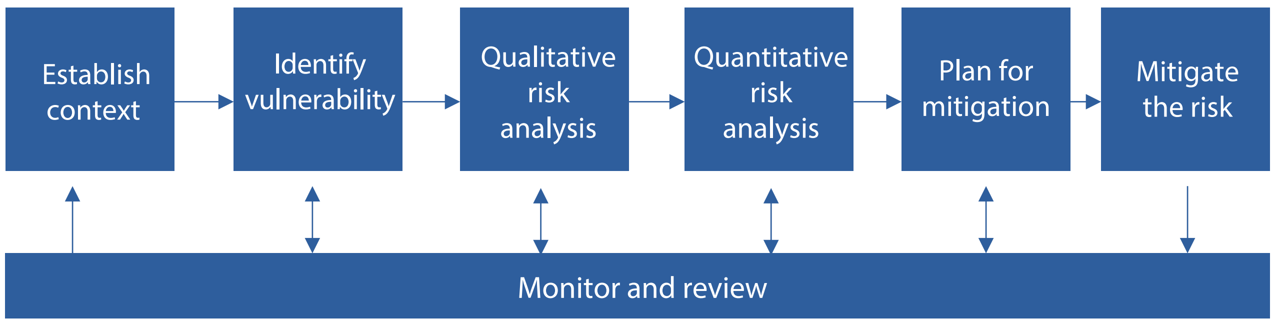
In advanced asset management practice, risk is increasingly being considered at all steps in the asset management business cycle. Risk assessment is a means of identifying critical assets and those assets that should not be permitted to fail, but it is also a way of addressing the consequences of factors such as having the wrong data, using forecasts that prove to be wrong or making the wrong decision. Risk permeates all business processes.

There are many potential sources of risk to a transportation agency. These can be grouped into four major areas:

- Natural events and hazards – These include floods, snowstorms, extreme wind, wildfires, landslides, tsunamis and earthquakes. While the probabilities and recurrence of these events may be understood, it cannot be predicted when exactly the next event will take place. These events cannot be controlled, although an agency can prepare and mitigate the effects in advance.
- External impacts on the agency – These include the failure of other parties or organizations to provide a service or product upon which the transportation agency depends. Examples can include the supply of power for traffic signals, lighting or other automated highway controls, or the supply of materials which are deficient in some way.
- Physical asset failures – These events are caused by poor or deteriorating condition or performance of an asset or asset component, leading to disruptions for users of the service or adverse effects on the environment and the need to undertake remedial work. Certain types of failures may occur suddenly and without warning, such as the fracture of structural steel. Other events can be better predicted using condition and performance monitoring programs and predictive modelling tools.
- Operational risk events – These events include vehicle operator errors like an impact by a vehicle (e.g., truck, train or ship) on a structure; vehicle equipment failures that cause fires or collisions; failure of safety features of the transportation system, such as lighting, traffic signals or railroad crossing gates; or intentional damage such as sabotage. Events may also include errors made within the organization; for example, management decisions or design errors.

Risks can be described in monetary (quantitative) or descriptive (qualitative) terms and used as performance measures for levels of service in much the same way as other performance indications. Risk can be considered in a variety of tasks, such as priority setting and resource allocation decisions, as well as in routine activities like setting intervals for asset inspection. A typical risk management framework is illustrated in Figure 12 below. This systematic process can be used for a wide variety of activities within an organization, ranging from specific projects to institutional management.

Figure 12
Possible risk management framework



Source: ibid., Andrzej Maciejewski.

3.5. Decision-making framework

The decision-making framework should embrace several steps, processes and methodologies that will lead to the definition of a list of prioritized investments (encompassing both maintenance and capital projects).

To cover all relevant issues the mature planning process – apart from the abovementioned processes – would cover[21]:

- Condition assessment
- Deterioration analysis
- Forecasting models
- Treatment efficiency analysis
- Optimized decision-making

3.5.1. Condition assessment

There are numerous publications and resources available which describe how to monitor the condition and functional performance of assets. It is important for an agency to keep abreast of new developments, tools, methods and standards in this area. Accurate asset condition and performance data collected over a period of time allows an agency to determine deterioration trends in relation to environmental and traffic factors, and to use this information to predict future behaviour.

Different examples of approaches to obtaining condition data include:

- Periodic assessment of 100 per cent of inventory (e.g., bridges)
- Statistical sampling based on attributes
- Random sampling of a population blind to the attributes

As well as the well-known and documented visual and laser scanning methods of gathering data about pavements, other techniques such as ground penetrating radar (GPR) can provide valuable insights about the nature and likely future behaviour of the pavement structure – for example:

- Pavement layer thickness
- Pavement layers de-bonding
- Voids or sinkholes
- Presence of underground utilities

Similarly, data on the following issues can be obtained for bridge decks:

- Delamination
- Rebar mesh depth and condition
- De-bonding
- Overlay thickness

The level of detail and time interval of inspections is generally determined by the needs of the most detailed business process using the inspection data.

Road authorities typically aggregate and summarize the data using standardized techniques, such as the health index, for business processes that do not need as much detail (for example, priority setting and funding allocation).

The American Federal Highway Administration (FHWA) sets policies for bridge inspection intervals based on an assessment of the risk of safety-related deficiencies:

- Bridges in excellent condition are at less risk and can be inspected less frequently than the standard two-year interval
- Bridges in poor condition or that are fracture-critical (might fail catastrophically if only one member fails) must be inspected more often because their safety risk is greater than average

Inspection cycles for assets which may deteriorate rapidly or are subject to environmental effects, such as wind or snow damage, may need to be more frequent, especially if the assets also provide a safety function. Signs and road markings are typical examples.

Cycle times can be established by considering information such as historic maintenance and replacement patterns, customer complaints, feedback from personnel and contractors, crash records, and whether an improvement in the level of service is required. Frequent inspection cycles will often be a routine function for maintenance crews.

21 Ibid., AASHTO.

3.5.2. Deterioration analysis

According to the AASHTO over the past few decades, an extensive body of literature has been compiled on the forecasting of infrastructure deterioration. The greatest amount of progress has been made on paved roadways, but bridge management is starting to make strides as well. Across all types of assets, two pairs of distinctions are used to classify the models:

- Mechanistic versus empirical – Mechanistic models are based on physical and chemical research on material behaviour, attempting to quantify laboratory results and the cause-and-effect relationship. Empirical models are based on readily observed data in the field, attempting to directly forecast the desired measures of condition without studying cause and effect.
- Probabilistic versus deterministic – Probabilistic models quantify a probability distribution of future outcomes, usually presented as a distribution among condition states. Deterministic models predict the most likely outcome, usually on a continuous scale.

All four combinations of these attributes have been applied in practice. In most cases, the choice of methodology depends to a great extent on the availability of data or a calculation of the benefit of more accurate or precise models, relative to the cost of data collection.

Often the choice of the most appropriate deterioration model is based on compatibility with existing data and on industry experience with the accuracy of each type of model. The state of the practice in deterioration modelling advances regularly.

There are strong interrelationships that influence the selection of condition recording schemes, deterioration models, and bridge or pavement management systems.

All these deterioration models are simple enough that they could be implemented outside pavement and bridge management systems (e.g., in Excel spreadsheets) for other types of assets. The calculations can turn out differently for different types of assets.

Most commonly today, pavement management systems rely on empirical deterministic models of measured data on continuous scales, such as the percent of surface area that is cracked. Bridge management systems rely on empirical models of visual classification of bridge elements, expressed probabilistically.

One of the earliest infrastructure deterioration models was developed for pavement management by the American Association of State Highway Officials (AASHO, now known as AASHTO) road test of 1958–1960 and elaborated in subsequent studies. The models developed in these studies popularized a widely recognized form for infrastructure deterioration models.

Later versions of deterministic pavement deterioration models also recognized that condition does not simply drop to zero but approaches zero asymptotically. This led to slightly more elaborate functional forms of the model that were more S-shaped. This type of empirical deterministic model remains the most common form in pavement management.

In the earliest applications of deterioration models to bridges, variations on the AASHO curve were common. Typically, researchers would use National Bridge Inventory (NBI) condition ratings to characterize performance. Unfortunately, these efforts encountered problems:

- Forecasts were not sufficiently precise when tested against historical data. The error spread was too wide to serve as a useful model for bridges.
- The regression methods commonly used for these models gave inaccurate results because the NBI condition scale is not continuous or uniform.

Recognition of these problems led to several innovations. First, the system for recording bridge condition data was improved by the adoption of the AASHTO CoRe Elements, which has separate information on the severity, extent and type of defects. Having better information on the condition meant that some of the broad cause-and-effect relationships of deterioration could be recognized, offering more detailed and precise forecasts.

Second, bridge engineers adopted a probabilistic form of deterioration model that was better suited for categorical data such as CoRe Element condition states. This was the Markovian model.

3.5.3. Forecasting models

Asset management systems frequently include capabilities to forecast other performance measures, besides condition, that may feed into mission performance measures. These include:

- Utilization Models – Most sizeable transportation agencies maintain network traffic forecasts which drive the transportation planning process. Corridor or road section growth rates are derived from this information and input into the pavement and bridge management systems. Forecast traffic volume derived from these growth rates may affect the rate of deterioration or the calculation of user costs due to roadway deficiencies. These models generally include the ability to model most, if not all, of these variables from one set of demographic and network data, thus simplifying processes and increasing confidence that each of the various outputs illustrate the effects of the same changes in input data, whether it is a demographic or network change or, more often, the results of both of these.

- Mobility Models – When traffic growth is combined with road section capacity, information can be derived to forecast congestion and travel time. This is often done as a part of an agency's planning process, but few agencies communicate this information to asset management systems for use in the planning of asset improvements.
- Safety Models – A few agencies have developed forecasting models to relate roadway characteristics to accident risk. Sometimes this information is converted to user costs. This helps to build a consistent economic justification for safety improvements.
- Externality Models – Transportation agencies may be required to have forecasting models for air and water quality, and may have studied other externalities such as noise, energy consumption and the impact of deteriorated infrastructure on property values. None of these models is yet connected to an asset management planning tool, but this is an attractive area for future work.

3.5.4. Optimized decision making

An approach to optimization which uses the results of predictive modelling together with failure mode analysis, economic analysis and risk management principles is described in the *International Infrastructure Management Manual*[22] (Section 3.4.5.3) as optimized decision-making (ODM).

ODM principles can equally be applied to asset preservation and replacement optimization as well as to optimization of new construction projects and improvements. ODM is a suitable approach to making decisions across different funding allocation processes.

The condition or functional performance of an asset deteriorates at varying rates throughout its effective life until it fails to achieve its required level of service or falls below a minimum condition standard.

ODM is a decision-making process designed to select the most appropriate or optimal treatment decision for addressing the decline and restoring the level of service, given the agency's business environment, risk profile and the nature of the assets. The process encompasses net present value analysis and risk assessment.

When carried out at a network level, ODM is used in conjunction with the models and tools described earlier in this chapter to help a road authority to answer important questions, such as:

- What will the condition of the network be in the future, given a specific budget?
- What budgets are needed to achieve a given set of performance standards?
- What is the optimal budget level?
- What treatments will be applied, when and where, to meet those standards?
- What treatments should be applied, when and where, if budgets are less than ideal?
- What will be the performance level of the network with constrained budgets?

The benefits an agency can accrue using a decision support methodology like ODM for project selection and priority setting include:

- Extension of asset life – This is the effect of the treatment option, the time period gained before the same, or another, treatment is required in order to continue to provide the required level of service.
- Reduced operation and maintenance cost – With assets in better condition after treatment, the operation and maintenance cost can be optimized and reduced with reduced likelihood of failure.
- Restored or enhanced level of service
  - Service delivery that is linked to agreed levels of service and cost
  - An improved planned maintenance environment that is likely to increase the reliability of the level of service that the facility provides
- Risk exposure reduction – ODM considers risk factors in decision-making which can lead to:
  - Avoidance of, or reduction in, risk exposure for critical assets subject to catastrophic failure modes
  - Reduction in the risks of failure of facilities that are critical in terms of the reliability and safety they provide, such as traffic signals, drawbridge and bascule bridge mechanisms, power supply, and other services that exhibit major differences in service delivery between their failed and operating states

The key life cycle asset management processes affecting ODM are:

- Prediction of future demand and levels of service required from customers
- Prediction of failure modes (or effective lives) of the assets
- Understanding asset condition assessment and functional performance monitoring
- Assessment of risk and application of risk management

[22] Ibid., Institute of Public Works Engineering Australasia.

Section 4: Benchmarking analysis for TEM member countries

4.1. Benchmarking of asset management practices in TEM member countries

For the purposes of this study, the assessment tool elaborated by the Conference of European Directors of Roads (CEDR) has been used to carry out benchmarking analysis for TEM member countries in support of their efforts at continual improvement of their asset management practices and to shape upcoming TEM strategic plans for the next programming period (2021–2026).

The conceptual model prepared by the Institute of Asset Management became the basis for the expanded approach adopted by the CEDR studies concerning road asset management. Building upon existing knowledge, the CEDR Task Group[23] identified five main domains (instead of the six presented in the Institute of Asset Management model above) which they considered to be embracing the implementation of asset management:

- Asset knowledge and information
- Strategy and planning
- People and organization
- Stakeholders and customers (including market approach and procurement strategies)
- Risk

4.1.1. Asset knowledge and information

Current practice in the TEM region is indicative of a medium to high level of maturity of asset knowledge and information.

The average survey result for the TEM member countries shows that their road authorities intend to put a strategy for asset information in place, that they have identified the means to achieving this and can demonstrate progress in the definition of an asset information strategy. However, processes are not yet well integrated, with limited consistency and coordination across the agency.

In some TEM member countries, road authorities have already developed an asset information strategy that is documented and consistent with the overall strategic documentation. The development of the asset information strategy considers the significance of identified risks to information requirements, the information required for key decisions and the exchange of information with stakeholders.

Only a few TEM member countries have an asset information strategy fully integrated with the relevant business processes and enabling technology. The road authorities have set the guidelines for the collection and registration of data and asset information, but the implementation of the guidelines in the recording process have not yet been achieved.

In terms of asset information systems, the road authorities either have such a system in place or already have implementation plans in place. The implementation approaches do vary; some road authorities have single-vendor solutions while others have assumed a multi-vendor approach.

4.1.2. Strategy and planning

On average, the road authorities in TEM member countries have identified the need to develop an asset management policy and can demonstrate that they are progressing with a credible and resourced plan. Some organizations have such a policy authorized by top management that have, moreover, communicated the policy to the employees and stakeholders.

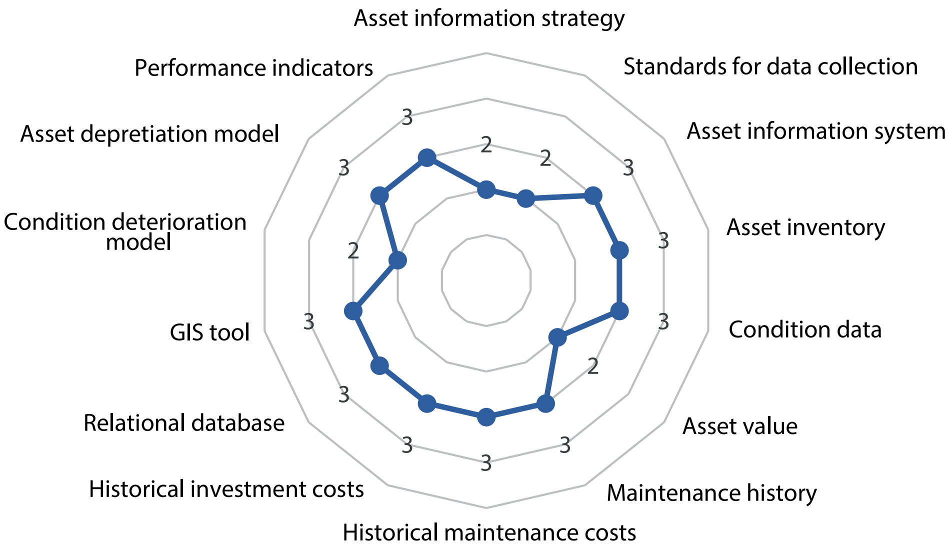
In these countries, the asset management policy provides a framework for implementation of the strategic asset management plans which is consistent with the organizational objectives.

It can be observed in a few countries that the asset management policy has relevant application in all parts of the organization. There is no road authority in the TEM member countries which does not recognise the need to have an asset management policy.

The road authorities systematically capture the requirements of external and internal stakeholders for asset creation and acquisition, and turn these requirements into clear statements of project purpose, outputs and outcomes aligned with asset management objectives.

23 Margo Briessinck and others, *CEDR technical report 2017/06 – TG Asset Management Final Report 2017*, Conference of European Directors of Roads (Brussels, CEDR Secretariat General, 2017).

Figure 13
Benchmarking analysis: asset knowledge and information



Source: ibid., Andrzej Maciejewski.

A number of alternatives, including innovative and no-asset solutions, are considered for achieving expected outcomes (level of service).

Configuration management for the main assets is done systematically across the road authorities. They have processes in place for assessing the impacts of planned changes and for managing the risks that arise.

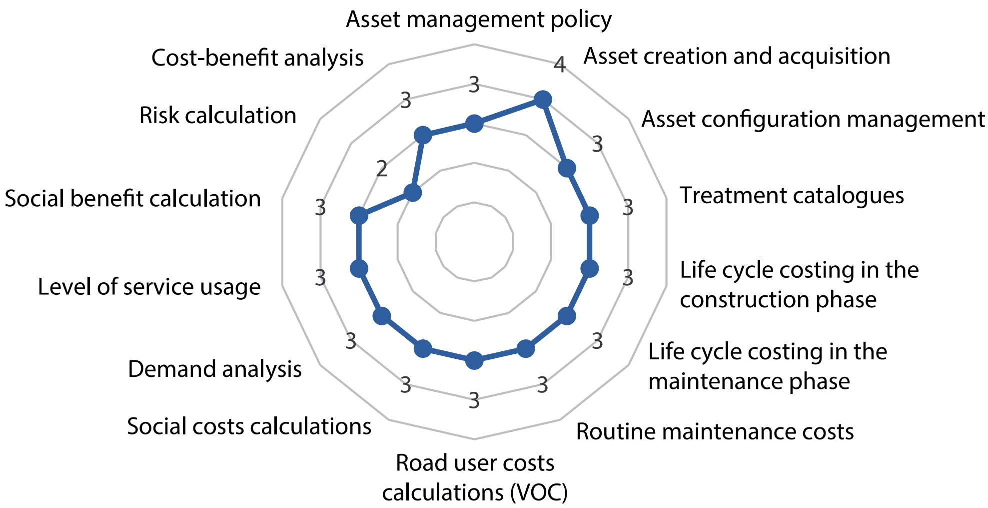
The organizations also have processes for internal and external dissemination of information that is relevant to their assets throughout those assets' lives.

The construction costs of each asset are calculated and registered in life cycle models in a systematic and consistent way.

The processes and methods for calculation of construction costs are aligned with the SAMP and are consistently applied across all assets. Risks and changes in the risk profile are taken into consideration when calculating the construction costs.

The road authorities have maintenance catalogues in place which determine and document the process and methods used in the maintenance strategy of their assets. The road authorities review the effectiveness of their maintenance strategies to ensure optimal delivery and adapt those strategies as the operating context, objectives and constraints change over time.

Figure 14
Benchmarking analysis: strategy and planning



Source: ibid., Andrzej Maciejewski.

Regarding periodic and routine maintenance, costs are calculated and registered in life cycle models in a systematic and consistent way.

TEM member countries systematically calculate road user costs as well as social costs.

The member countries use demand analysis to identify internal and external factors that may pose risks to achieving the asset management objectives and forecast how these factors can influence the demand for services in the future.

All the road authorities have developed levels of service together with quantitative tools and techniques for forecasting required levels of service, but the results of level-of-service analysis are not always taken into account in setting the asset management objectives and developing asset management plans.

4.1.3. People and organization

On average, the road authorities have in-depth knowledge of ISO 55000 et al. All the organizations set objectives and targets for all areas of their responsibility (supported by key performance indicators).

They have defined 5–10-year strategic business plans, but it is not common to have strategic documentation and asset management related issues. Typically, the plans are not integrated and do not align with the asset management needs of the organizations. However, the road authorities set measurable, achievable and realistic objectives that are documented, creating a sound basis for improvements.

The majority of road authorities have defined their resourcing and competence strategies and are in the process of implementing a competence management system to support the recruitment, training and development of the staff.

They have defined competence management strategies and are in the process of implementing a system to identify the required asset management roles and competency requirements for asset management activities, and are evaluating the performance of individuals.

A competence management strategy helps to identify objectives, roles and responsibilities of individual staff members and aligns personnel with the organizational objectives.

Figure 15
Benchmarking analysis: people and organization

Source: ibid., Andrzej Maciejewski.

4.1.4. Stakeholders and customers

The road authorities specified and clearly documented the criteria for the selection of service providers, the service levels, the requirements, the scope and the means of information sharing for outsourced activities. In general, it is ensured that outsourced activities are consistent with the asset management system requirements.

A majority of those countries which took part in this study use key asset information to support funding submissions based on condition, deterioration and other forecasting models to predict the deterioration of the most critical assets.

They also identify asset management activities which are appropriate for outsourcing and those which should remain in-house. The organizational resourcing strategy includes the development of clear criteria and service levels for outsourced activities.

Road authorities ensure that outsourced activities are controlled and integrated with the asset management system and that they meet requirements of competency, awareness and documentation consistent with asset management system requirements.

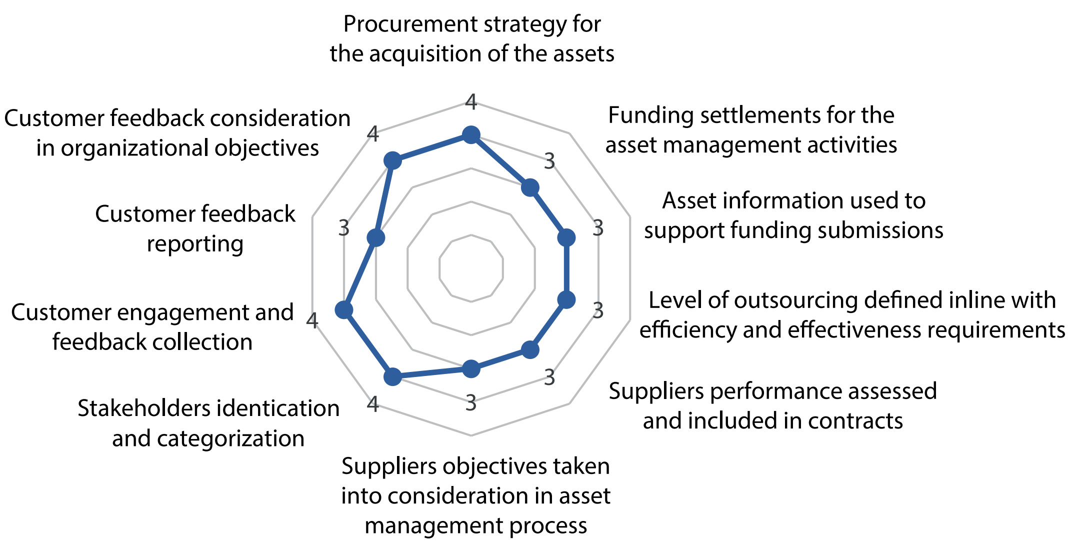
The outsourced activities are adequately monitored through performance indicators. Moreover, they monitor suppliers' commercial circumstances and ownership structure to ensure relationship viability and longevity.

Regarding customers, the road authorities have a stakeholder identification and categorization process in place which is aligned with the overall asset management system. It takes into account the agencies' external and internal contexts, being periodically revised to ensure that the process remains effective.

The authorities ensure customer engagement by carrying out customer surveys using written questionnaires and face-to-face interviews. Customer consultations are conducted in formats, languages and a level of detail suitable to the needs of each category of customer.

The information collected is directly sent to the concerned functional departments or units for their consideration. An integrated system for response and management of customer comments and feedback is being developed.

Figure 16
Benchmarking analysis: stakeholders and customers



Source: ibid., Andrzej Maciejewski.

4.1.5. Risk management

Risks are considered by asset type but not necessarily for the overall asset portfolios. In addition, while asset life cycle considerations may be taken into account during risk identification at every stage of the asset life, future risks are not systematically incorporated in the risk management process.

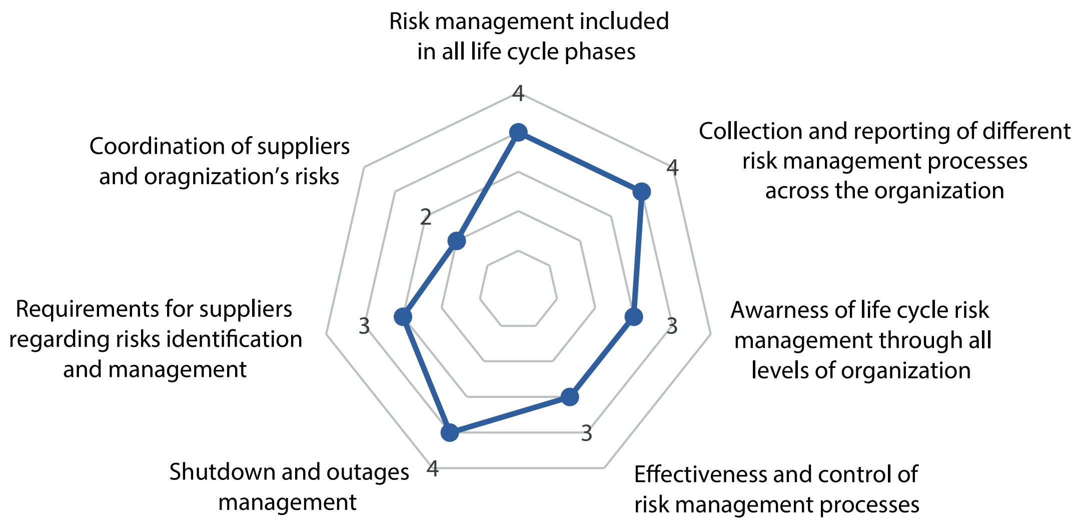
The road authorities have defined a collecting and reporting process in order to communicate risks upward in the organizations. However, only the main risks are included in this process, while the rest are managed at department or unit levels. Some implications are not therefore clearly understood or managed.

A majority of respondents evaluate the effectiveness of individual actions to address risks and opportunities at a local or functional department or unit level. For now, monitoring on the whole organization level happens only in a few road authorities.

The road authorities manage shutdowns and outages at a local level or within functional departments often in a reactive mode. In most cases, however, the road authorities are developing the necessary processes to manage these activities in a preventive and more efficient way.

Main suppliers are required to have a risk management process in place in order to identify and manage risks associated with their activities. Their risks are also taken into consideration but only for the main outsourced activities and for the main risks anticipated.

Figure 17
Benchmarking analysis: risk management



Source: ibid., Andrzej Maciejewski.

Section 5: Conclusions

Asset management practice in the TEM member countries is, in general, well recognized, and the majority of road authorities within the region have mature asset management systems already in place. This creates a sound basis for further cooperation among TEM member countries, with a focus on the particular elements of the asset management framework.

Considering the results of the conducted benchmarking analysis, the main focus going forward should be on risk management, which seems to be the most challenging part of the overall framework.

Regarding the management of stakeholders and customers, road authorities have years of experience in the processes of consultation during capital project delivery.

What could become an important topic is further international cooperation and the potential creation of common standards for addressing customer feedback in the management of the overall TEM network.

What may need to be reflected in the upcoming strategic plan of the TEM Project are activities which will help to better align the management of organizations with asset management systems and objectives.

Finally, it is advisable to create common standards for asset information strategies and data collection. This can help in the future to create a comprehensive database with asset related information to supplement already collected information for the purposes of TEM Backbone Network reporting.

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Tools for asset management: TEM recommendations for road operators

The Trans-European North-South Motorway (TEM) Project was initiated to facilitate road traffic in Central, Eastern and South-Eastern Europe and to assist with the process of integrating European transport infrastructure systems.

In order to improve the road network's management, the Project provides TEM member countries with benchmarking of the current capacities of asset management, with up-to-date information on how to address the value creation process in their procedures, competencies and supporting information systems.

Asset management is understood as an ongoing value creation process that can be exercised with greater or lesser situational awareness on the part of the asset's owner and manager. The level of awareness is reflected in the maturity of existing asset management systems within TEM Project member countries.

This high-level benchmarking of TEM member countries' management capacities and tools can improve the asset management process both for individual project members and for the TEM network as a whole.

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