PERFORMANCE INDICATORS TO SUPPORT EVALUATION OF ROAD INVESTMENTS

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Abstract

Transportation planning recognizes the critical links between mobility and other goals of society. Strategies supporting infrastructure investments lead to substantial public interest because they relate to public expenditures. Decision processes related to transport projects involve considerations on environmental, economic, technical and safety issues, and are characterized by many actors and multiple objectives in feasibility studies.

This paper compares performance measurement approach in road management and compares them with current practice in Estonia emphasizing the importance of feedback from previous projects. The need to compare predicted inputs, outputs, costs and benefits with actual performance is brought up. Lifecycle approach performance measures are presented that allow government and transportation agencies to consider road construction and rehabilitation strategies more effectively.

Keywords: transport policy, infrastructure investments, feasibility studies, road network, performance indicators

JEL Classification: O18, R42

Introduction

A modern transport system must be sustainable from an economic, social and environmental viewpoint. The performance of the transportation system affects public policy concerns like economic development, safety, and security, air quality, consumption of other environmental resources, social equity, land use, and urban growth. Transportation helps shape an area's economy and quality of life being a major component of economic activity, both in itself and as an input factor to most other sectors.

Transport systems need to be reliable and sustainable to support economic growth. Freight and passenger services strongly support international trade. Infrastructure investments are a key determinant of performance in the transport sector. Governments' ability to provide infrastructure is limited by the availability and scarcity of resources. Precisely because of these resource limitations, the pursuit of efficiency – i.e. the best possible use of available resources – is at the core of the decision regarding which project to finance (Haas *et al*, 2009).

Due to the social impact, determining role in economic growth and the scale of these investments the risk of errors in judgment should be minimized. During the last decade performance measurement systems have been studied particularly as it applies to road and transportation systems to avoid transport investment risk. Several factors have encouraged this trend toward using performance measures in transportation planning and programming, including:

- desire to increase the accountability of public expenditures;
- need to communicate results to public and to get their support for investments by focusing on results in the face of reduced resources;
- responsiveness of state and municipal statutes (Performance..., 2006).

In this paper the authors have reviewed practices of performance measurement in road construction in different countries, what the appraisal methods for road investments like and how feedback is gathered. Based on the results of other countries practices a set of performance indicators are presented to be considered for evaluation of the road network condition and feedback.

In the United States, United Kingdom, Australia, Canada, Belgium, Denmark, Finland, Hungary, Japan, Netherlands, New Zealand, Portugal, Sweden and Switzerland transportation agencies have conducted research as to why performance measurement in road construction is important, how it should be undertaken, and what is typically measured. This has led to developing and implementing performance measurement indicators for road agencies to evaluate their whole road networks (Performance..., 2001; Transport…, 2008).

These implemented performance measurement systems focus on agencies strategic goals and the outcome of individual road construction projects cannot be identified. Over the past decades, pressures (axle load, number of vehicles, traffic frequency) on the road networks have increased. This has resulted in accelerated road damage and increased demand to develop and upgrade the road network. There is a need to report and communicate how public funds are used to maintain and develop the system and the effect of expenditures upon it.

The ability to perform life-cycle economic analysis associated with infrastructure assets is important to long-term sustainability. To be able to identify if finalized development projects have met estimated financial, environmental and social indicators as predicted is essential to that process. The ability to measure the success of finished projects can help governments or road agencies to use their limited resources more effectively. Performance measures offer a powerful tool for setting objectives, focusing resource allocation decisions, measuring results and improving accountability. This paper aims to emphasize the importance of continuous performance feedback from transportation projects throughout the lifecycle due to the rich support of decision process it can give to new transport projects and development of policies.

1. Transportation Policy and Planning

Transport policies arise because of the extreme importance of transport in virtually every aspect of national life. Transport is taken by governments of all types as a vital factor in economic development. Transport is seen as a key mechanism in promoting, developing and shaping the national economy.

Transportation policy planning is a cooperative process designed by the governmental or local agencies to foster involvement by all users of the system such as the general public, the business community, community groups, environmental organizations, the traveling public and freight operators through a proactive public participation process (Rodrigue *et al*, 2009; Litman, 2011) This co-operation and input from all interest groups results in developing and implementing a regional or state transportation policy (see Figure 1).

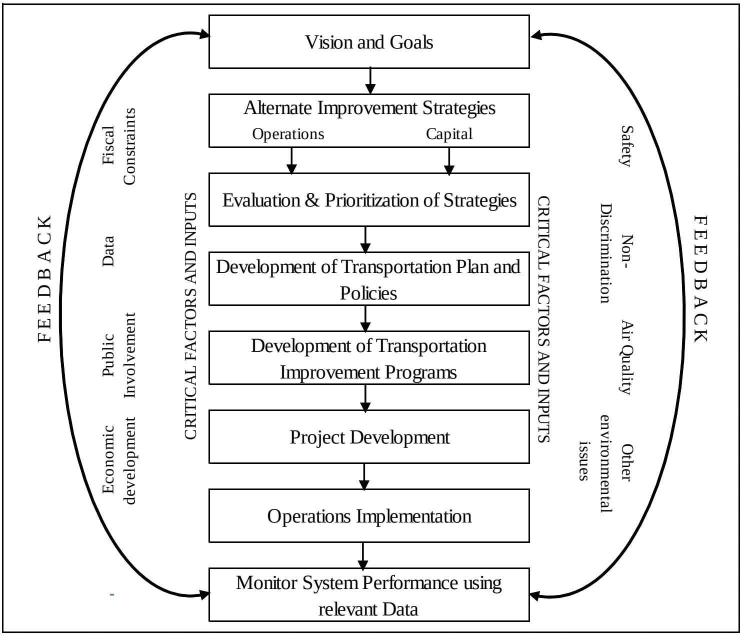

Figure 1. The transportation policy-making and implementation process (Adapted from The Transportation..., 2007).

Transport policy is the development of a set of constructs and propositions that are established to achieve particular objectives relating to social, economic and environmental development, and the functioning and performance of the transport system. Transport planning deals with the preparation and implementation of actions designed to address specific problems. A major distinction between the planning and policy is that the latter has a much stronger relation with legislation. Policies are frequently, though not exclusively, incorporated into laws and other legal instruments that serve as a framework for developing planning interventions (Rodrigue *et al*, 2009).

Transportation policy should state the government's primary goals for transport system investments. Four key goals are recommended to be set by national transportation policy, all of which are critical to the national interest, require state level leadership and action and are intrinsically of national nature:

- Economic Growth – producing maximum economic growth per monetary unit of investment;
- Metropolitan Accessibility – providing efficient access to jobs, labor, and other activities throughout metropolitan areas;
- Energy Security and Environmental Protection – integrating energy security and environmental protection objectives with transportation policies and programs;
- Safety – improving safety by reducing the number of accidents, injuries and fatalities associated with transportation (Performance…, 2009).

International experience indicates that diverse problems of transport sector are closely related with each other as they have similar causes and do not necessarily depend on the peculiarities of a transport mode. The main obstacles to the sustainable development of transport arise from one of the following four issues:

- Inadequate planning;
- Inadequate infrastructure quality;
- Issues of safety and security;
- Adverse environmental effects (Campbell *et al*, 2008).

Consequently, transportation policy needs to be performance-driven, directly linked to a set of clearly articulated goals and accountable for results. If a transportation policy has lost direction and a clear sense of purpose, it has substantial costs to collective prosperity, security, environment, and quality of life. In many countries the extensive investments into highway networks, begun more than 50 years ago, that are now nearing or beyond their intended lifespan. Existing systems are dated, in many cases strained to (or beyond) capacity, and increasingly fall short of delivering transportation services at the level of quality, performance, and efficiency the public demands. Current funding mechanisms are not sufficient to maintain existing infrastructure, let alone provide the investments needed to expand and modernize the transportation systems. The broader fiscal outlook is suggesting that public resources will be more constrained than ever in the years ahead. Available resources cannot be distributed without a strong sense of national priorities, and recognition of the link between transportation investments, energy, and climate (Performance…, 2009).

For example, in the United States the importance of performance measurement in transportation projects was clearly stated in 2009 during the development "The New

Performance Driven Vision for U.S. Transportation Policy". Previously there was no federal requirement to optimize returns on public investments, and current programs were not structured to reward positive outcomes, or even to document them. Without clearly articulated goals, there was little accountability for the performance of most federal transportation programs and projects to that date. The result had been an emphasis on revenue sharing and process, rather than on results (Performance…, 2009).

However, as the pre-existing problems on the list, is placed in the centre of the need to learn from past projects carried out in order to avoid irrational spending of resources. The same questions can be posed whether and how to develop a performance measurement system for road transport and to carry out the investment follow-up audit linkage with formal decision-making procedures, incl. use of appraisal methods.

2. Interaction between feasibility studies and performance measurement systems

2.1. Appraisal methods for road projects

Investment appraisal is an important issue in transport planning and policy. The investments are usually long lasted, practically irreversible, costly and may at the same time have great impact on people's lives and the development of communities and regions. The evaluation of projects should identify key consequences of proposed project and provide quantitative information about them. The various types of effects should then be made comparable, so that a choice can be made in the typical case where different project alternatives would score better on different criteria, and no strictly dominant alternative is available. Investment decisions should therefore be well thought trough, and various alternatives should be compared carefully before making final choice.

Public sector investment appraisal has to take into account externalities generated by proposed transport projects. The range of effects that have to be taken into account with the investments of a road is wide (see Appendix 1). The wide range of effects may make it very difficult for policy makers to decide whether a project is worthwhile to undertake, or to rank competing projects. A skillfully performed projects appraisal will structure the information. The rise in the development of appraisal techniques for transport projects came in the late 1960s and early 1970s. Cost-benefit analysis (CBA) is the common bases for most appraisal networks (Grant-Muller *et al*, 2001).

CBA offers a framework for evaluating all social costs and social benefits of an investment project - including externalities. CBA essentially compares the projected future stream of benefits from project with its initial and future costs. It thus allows a ranking of several competing projects or project variants, or a decision not to undertake any of these. Investment decisions on transport investment are usually made by public authorities, often motivated by infrastructure's "public good" character. Two major weaknesses often mentioned are the unavailability of accurate estimates of shadow prices for various effects, and the method's assumption that different types of effects can be regarded as they can be traded off on "dollar to dollar bases" (Nijkamp *et al*, 2002). As a consequence several complementary approaches have been deployed, such as cost effectiveness analysis, planning balance sheet methods and shadow project approaches. Multi-criteria analysis (MCA) is often seen as competing with CBA, even though there is no fundamental reason why these two approaches may not be used in an entirely complementary manner within an overall framework (Grant-Muller *et al*, 2001).

Therefore, investments in road infrastructure development may not be evaluated using only traditional appraisal methods such as the Net Present Value (NPV), Internal Rate of Return (IRR), Accounting Rate of Return (ARR), Payback Time etc. This is due to the fact that road infrastructure comes with other social and economic benefits that are difficult to quantify in monetary terms. Development projects impose a series of costs and benefits on recipient communities or countries. Those costs and benefits can be social, environmental, or economic in nature, but may often involve all three. Public investment typically occurs through the selection, design and implementation of specific projects to achieve the goals of policy (Adu, 2009).

An international effort to develop improved road investment appraisal methods was undertaken in 2001 by the British Overseas Development Administration, the Asian Development Bank, the Swedish National Road Administration, The Inter-American Federation of Cement Manufacturers, and the World Bank. Since then the Highway Design and Maintenance Standards Model (HDM-III), developed by the World Bank has been used to combine technical and economic appraisals of road investment projects, and to analyze strategies and standards (Archondo-Callao, 2008).

HDM-IV broadens the scope of such models beyond traditional project appraisal, providing a powerful system for the analysis of road management and investment alternatives. A completely new software package was developed and associated documentation which will serve as the primary tool for the analysis, planning, management and appraisal of road maintenance, improvements and investment decisions that will supersede HDM-III. The HDM-IV model is based on the concept of pavement life-cycle analysis and uses three sets of models: a) road deterioration - which predicts pavement deterioration; b) works effects - which simulate the effects of road works on pavement condition and determines the corresponding costs; and c) road user effects - which determine costs of vehicle operation and travel time (Gerbrandt and Berthelot, 2007).

HDM-IV simulates total life cycle conditions and costs for an analysis period under a user-specified scenario of circumstances. The primary set of costs for the life cycle analysis include the costs of capital investment, maintenance, vehicle operation, travel time, and accidents as an option. The cost of environmental pollution is not currently included, but will be added in a later release. The broad concept of the life cycle analysis is illustrated in Appendix 1. Interacting sets of costs, related to those incurred by the road agency and those incurred by the road user, are added together over time in discounted present values. Costs are determined by first predicting physical quantities of resource consumption and then by multiplying these quantities by their unit costs or prices. Economic benefits are then determined by comparing the total cost streams for various maintenance and construction alternatives with a base case (do nothing or do minimum alternative), usually representing minimal routine maintenance.

In the infrastructure project economic evaluation, two project alternatives are evaluated: a "without project scenario" and a "with project scenario". Annual road agency and road user costs are computed for both alternatives over a defined evaluation period, and total costs to society are compared for the two scenarios. It is desirable that more than two project alternatives can be evaluated per project, which permits the economic comparison of the project alternatives and the recommendation that the project alternative that maximizes the project's NPV can be implemented.

Hereby project analysis of road investments is concerned with the evaluation of one or more road projects or investment options. The application analyses a road link or section with user-selected treatments, and associated costs and benefits, projected annually over the analysis period. Economic indicators are calculated for the different investment options. Project analysis may be used to estimate the economic or engineering viability of road investment projects by carrying out the following (Kerali et al, 1998):

- Life cycle predictions of pavement performance;
- Estimation of maintenance and improvements effects and their costs;
- Calculation of road user costs and benefits;
- Prediction of environmental effects;
- Economic comparisons of project alternatives.

The primary effects are reduced vehicle operating and capital costs, reduced journey time, changes in road maintenance costs, changes in accident costs, increased travel, environmental effects, change in value of goods moved. Secondary effects are changes in agricultural output, changes in services, industrial output changes, changes in consumer behavior, change in land values. Benefits from road investments are changes in transport costs which occur because of lower road roughness, shorter trip distance, faster speeds, reduced chance of impassability, reduced traffic ability problems, change in mode (Hine, 2008).

2.2. Performance measurement in road management

Measurement of performance and productivity has gained significant interest recently among both academics and practitioners. Much progress has been made on establishing performance management systems (PMeS-s) which include a portfolio of measures aimed to balance the more traditional, single focus view on profitability. In this article the following definitions are used (Neely *et al*, 1995):

- Performance measurement can be defined as the process of quantifying the nature of operation;
- A performance measure can be defined as a metric used to quantify the nature of operation;
- A performance measurement system can be defined as the set of metrics used to quantify and qualify the nature of operation.

Performance measurement describes the feedback or information on activities with respect to meeting strategic objectives. They are used to measure and improve the efficiency and the quality of the production processes, and identify opportunities for progressive improvements in process performance. Traditional measures, however, are usually ineffective barometers of performance because they do not isolate non-value-added costs. In addition, most measures overlook key non-financial performance indicators (Wegelius-Lehtonen, 2001).

The traditional distinction of good and poor project performance focused on the meeting of cost, time and quality criteria, which has been described as the iron triangle (good-fast-cheap) of project management. Using the iron triangle as a measure has led the construction industry to witness examples of poor performance. Since 1980 other measures of performance have been developed, with the redefining of what constitutes good and poor project performance. Performance is now rather measured using various criteria, by different groups of people, at different stages in a project's life, which has been described as a multi-dimensional and multi-observational approach (Shenhar and Dvir, 2007).

According to literature contemporary PMeS should meet the following criteria: support strategic objectives; have an appropriate balance; have a limited number of performance measures; be easily accessible; consist of performance measures that have comprehensible specifications (Tangen, 2004). Other issues that should be considered selecting performance measures to evaluate a road network include forecast ability, clarity, usefulness, ability to diagnose problems, temporal effects and relevance (Performance..., 2006).

Generalizing previous authors argue that the factors that definitely should be PMeS-s for Road Management to consider are: the purpose of the measurement; the level of detail required; the time available for the measurement; the existence of available predetermined data; the cost of measurement.

Performance measures are classified in several ways in the literature. Measures are grouped, for example, into improvement and monitoring measures. Improvement measures are vital when starting new development and cooperation projects. The need for that kind of measures is obvious: if you do not know your current practices, you can not develop your operations further effectively.

The second group of measures consists of monitoring measures. These measures are needed for screening and controlling every-day actions continuously. Commonly the literature treats only these measures. There are several very good examples of PMeS amongst road agencies, which all monitor the existing network and give feedback about the conditions but do not give any feedback to the appraisal models in order to improve the decision making process (Wegelius-Lehtonen, 2001).

Performance measures are often described as input, output or outcome measures too. Input measures look at the resources dedicated to the project, output measures look at the product delivered, and outcome measures look at the impact of the products on the goals of the agency. Although outcome measures are generally preferred, transportation agencies need to consider data availability, cost and validity when developing their system measures. Some agencies are trying to implement performance measures in an integrated manner to set policy, allocate resources, and measure and report results. Thus, as transportation planning becomes more closely related to broadly defined policy goals, there needs to be greater participation by numerous disciplines in defining terms and in designing measurement approaches.

Over the past two decades, transportation agencies worldwide have developed various highway asset management systems such as pavement, bridge, maintenance, safety, and congestion management systems as analytical tools to help them make cost-effective investment decisions. In general, each road management system generally performs the following tasks:

- establishing highway system goals and performance measures;
- monitoring the performance of physical highway assets and system operations;
- predicting performance trends over time;
- recommending candidate projects to address system needs;
- carrying out project evaluation;
- conducting project selection;
- providing feedback to refine the analysis in subsequent decision cycles (A Guidebook..., 2012; Li et al, 2011; Multi-criteria..., 2009).

The underlying rationale for having performance indicators or measures is that the limited availability of resources for road infrastructure makes it necessary to allocate these resources as efficiently as possible among competing alternatives. Consequently, any framework for performance indicators should be comprehensive enough to incorporate functional, technical, environmental, safety, economic and institutional considerations. Cost, performance, service delivery and safety are front and centre in most transportation decision-making.

Studies that measure the impacts of planning before and after implementation can help determine whether specific forecasts are accurate and what investment decisions and planning efforts should be addressed or reevaluated. In practice, however, there is variation in the terminology. It includes performance measures, which is the term used in survey of Canadian Road Networks (Performance…, 2006), key performance indicators, which is a term originated in Australia for the performance specified road network contracts (Australian…, 2011), performance indicators, which is used in the European Harmonization on Performance Indicators in their COST-Action 354 for Road Pavements, and others. The usage herein is the term performance indicators, which accords with World Bank performance based contracting practices. In essence though, performance measures, performance indicators and key performance indicators have been used commonly and interchangeably in the roads sector.

3. Performance measurement in Estonian road industry
3.1. Estonian transport policy and road management

Given the infrastructure investment as a key prerequisite of economic development, in Estonian transportation policy is incorporated into the following legal instruments that serve as a framework for developing planning interventions: Estonian National Strategic Reference Framework 2007-2013, Operational Program for the Development of Economic Environment, Operational Program for the Development of the Living Environment and State Budget Strategy 2012-2015, Estonian Transport Development Plan for years 2007-2013.

The basic goals of the national transport policy are focused on sustainable development of the road and railway infrastructure of national and international importance, improvement of the traffic safety, encouragement of maritime navigation, integration of national transport system in the EU transport networks, achievement of balance and development of links between different transport modes. Achievement of these goals is a pre-condition for sustainable and balanced long-term economic growth (Transport…, 2007).

Estonian Transport Development Plan has been approved by the Parliament as a national development plan in the field on transportation. It is developed for introducing consistent measures at national or local level in the context of other policies:

- economic policy to be formulated to take account of certain factors which contribute to increasing demand for transport services;
- urban and land-use planning policy to avoid unnecessary increases in the need for mobility caused by unbalanced planning;
- social and education policy, with better organization of working patterns and schools' locations to avoid overcrowding roads;
- urban transport policy in major conurbations, to strike a balance between modernization of public services and more rational use of the car;
- budget and fiscal policy to achieve full internalization of external – in particular environmental – costs and completion of a transport network worthy of the name;
- research policy to make the various efforts made on national and regional level more consistent, along the lines of the European research area.

The Transport Development Plan 2007-2013 comprise two main parts – a descriptive analysis of the existing situation and the objectives set and measures and lines of action foreseen in the Development Plan. The list of the measures is not exhaustive as concrete actions are determined in annual implementation plans (Transport..., 2007). Figure 2 shows that during 2008-2010 the yearly average budget of road management was 312 mln EUR, comprising 174 mln EUR of investments in reconstructing national roads per annum. In Estonia, during the past years, 20 % of all investment made into the real sector have been investments in road management.

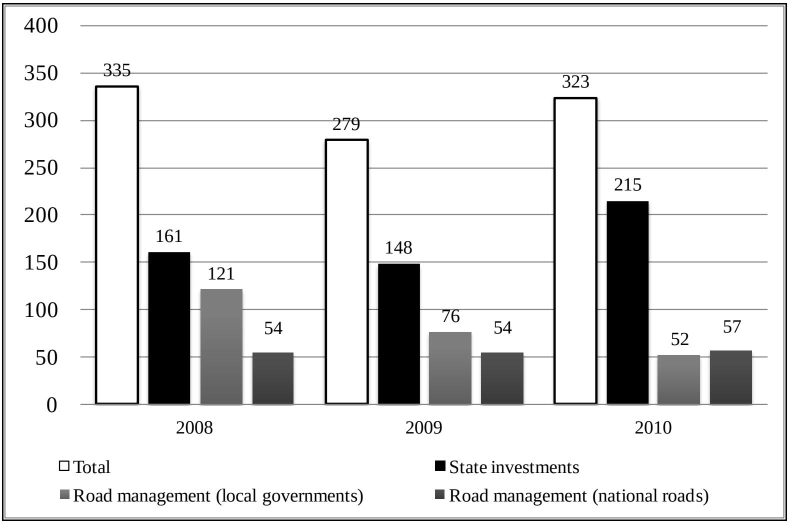

Figure 2. Expenditures for road management in Estonia 2008...2010 (mln euros) (Adapted from Sikk, 2008; Annual..., 2011).

According to the White paper of the European Transport Policy (2011) 30 % of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50 % by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed. This can be concluded that EU structural funds in the new financial perspective will be decreasing notably in road network development and increased notably in rail and maritime transport.

The significance of social benefits gained with the investment is planned to play a more determining role in investment decisions. In February 2012 the Ministry of Economic Affairs and Communication of Estonia (MoEC) started the drawing process of Transport Development Plan within the EUs new financial perspective, which has critical implications for transport infrastructure investment prioritization in avoiding the mistakes of earlier periods.

There are initially two key drivers for infrastructure investment requirements. One is GDP growth which, in turn, is a function of such factors as population increase, per capita income and productivity growth. The second is the existing stock of infrastructure, which creates a demand for periodic renewal. Therefore, as stated in previously, infrastructure investments are a key determinant of performance in the transport sector.

In Estonia the existing infrastructure network covers all areas from the accessibility goal, also due to low density of population we have very few areas where is congested and new developments do not give significant savings in travel times. New developments currently focus on upgrading the existing roads to highway standards or creating city bypasses - the greatest task is to maintain the existing road network and ensuring its sustainability.

3.2. Current performance measurement practice and implications for the future

The work of road administration authorities involves evaluating the technical and economic feasibility of undertaking alternative road construction techniques. The Estonian Road Administration (ERA) is a government agency operating under the auspices of the MoEC. It has a management functions, it carries out state supervision, applies the enforcement powers of the state and provides public services on the basis and to the extent prescribed by law. In performing its duties the ERA represents the state. One of the main tasks of the ERA is road management and creation of safe traffic conditions on roads. To achieve that aim, it is essential to get feedback from road users. Since 2002, the ERA has conducted surveys of the drivers` satisfaction with the driving conditions on national roads (Annual…, 2011).

Measurements of road surface roughness (according to the International Roughness Index, IRI) have been carried out and inventories of defects on paved roads have been made since 1995. The load bearing capacity (Falling Weight Deflectometer, FWD) of the roads has been measured since 1996 and rut depth since 2001. These four indicators of road surface condition together with the traffic volume are the main indicators of the Pavement Management System (PMS). Data about the condition of road surface is a part of the data in the National Road Databank and is publicly available. Two kinds of software – Estonian Pavement Management System (EPMS) and HDM-IV are used for analyzing the condition of road surface (Annual…, 2011).

The developed road construction projects are monitored and supervised very tightly during the construction process and also during the liability period. After the end of liability period regular surveillance of the road conditions as described before is carried out in a well regulated way, but without any feedback and comparison to the initial analyses, including meeting the feasibility calculations and durability of materials and comparing estimated repair span to the actual need during the lifecycle (see Figure 3).

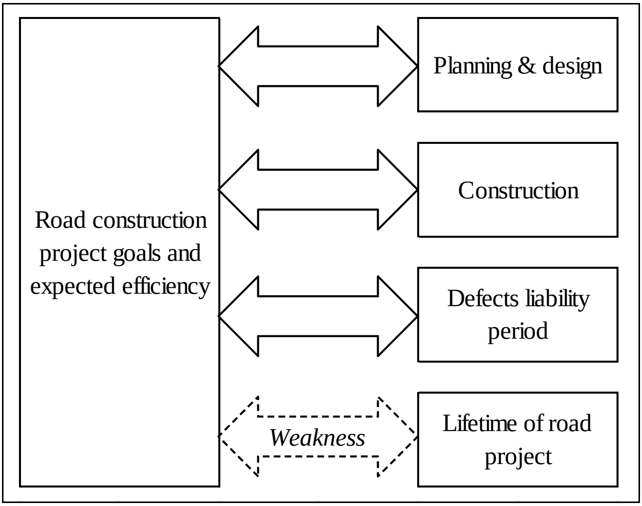

Figure 3. Current practice of road construction projects evaluation in Estonia (Kaare and Koppel, 2012).

Performance measures and corresponding data can be used to provide feedback to the relevant decisions (see Appendix 2). Good decision making requires a continuous reassessment of choices made in the past. Individual decision makers may learn from their own mistakes, but it is important that lessons be learned in a more formal and systematic way, and communicated to others, so that they can inform future decisions (Multi-criteria..., 2009).

Therefore, monitoring and feedback are critical components of performance-based planning that includes the ongoing monitoring of system performance and the appropriate feedback to the planning and decision making processes. This step is usually completed with observed data of actual system conditions and performance. Synthesized or forecasted data may be substituted for observed data in some cases, for example, where it is desirable to track the expected future outcome of an investment decision with a long-term payback period. At all levels of government, effective, performance-oriented project management is needed – management that focuses on project quality and on the results achieved through the use of tax revenue and other public resources (Wholey and Hatry, 1992).

Transportation agencies like ERA have usually a wealth of data available related to the services they provide and the infrastructure they maintain. The challenge facing managers is to gather and analyze data in a way that provides timely information on whether they are consistently meeting their strategic goals. Whenever the goals are not being met, management must use information to identify changes (Kaare and Koppel, 2012). Taking into account the abovementioned the following performance indicators are proposed to be gathered in Estonia throughout the life-cycle of a project (see Appendix 3).

The selection of indicators was performed by studying international practices, taken into account the special features of Estonia and the availability and accessibility of data. The presumption that the authors made was that the necessary data was already exist in databases or very easily collected, so that extra costs will be not created for the road agency. The proposed database has to take into account the rapid development of technology allowing the system to be flexible in implementation. Two issues which are of key importance and need to be addressed in future work are determining the appropriate design for the data collection activity are the anticipated use of, and planned method of storage of the collected data.

Information technology (IT) provides the means to store, manipulate, and disseminate massive amounts of data. The integration of IT at all levels of the transportation system creates the intelligence in intelligent transportation systems (ITS). But this integration is a long and difficult process of searching for and exploiting opportunities in the interconnected operations, planning, and funding of today’s transportation systems (Varaiya, 2002).

For example, the proposed indicators emphasize temperature, both of pavements from the safety aspect and in bound layers as an important technical indicator. This is due to the severe climatic conditions in Estonia with sometimes several melt-thaw cycles per day call for new IT solutions in road monitoring. Many technologies are not suitable due to shifting and subsiding effect of melt thaw cycles causing unsustainable failure of these solutions. By contrast, recent tests using sensor based RFID tags have given positive feedback and have proven to be sustainable (Kaare and Koppel, 2012). Also the use of different accelerometers to measure the overall pavement condition and roughness is widely spreading and is recommended for implementation due to the solutions’ low cost and wide accessibility.

Different countries, regions or road agencies have developed their PMeS that vary in chosen indicators due to on transportation policy goals, regional diverseness and inequalities, but the majority of them focus on overall performance measurement of the road network. Constructions companies measure the financial and organizational performance of individual road construction projects concluding the evaluation when the final acceptance certificate is issued or when the liability period ends. For the road agencies who take over the responsibility to maintain the constructed road during its lifetime it is important to monitor the performance to get feedback about the roads’ sustainability.

Conclusions

Transport policies arise because of the extreme importance of transport in virtually every aspect of national life. Several countries have recently stated that their transport policy needs to be performance-driven, directly linked to a set of clearly articulated goals and accountable for results. Road agencies face funding constraints and limitations, therefore performance measures are needed to evaluate the state of assets, which leads to developing priorities and allocating resources amongst competing projects.

Investment appraisal is extremely significant in transport planning and policy. The effectiveness of a road investment is determined by the costs of construction, annual maintenance and the reduction in user costs; components that, in general, constitute the total transport cost or life cycle cost of the road. Feedback in reporting about successes, opportunities, environmental impacts of the constructed or renewed road an essential in planning and evaluating new developments. Indicators proposed by authors are a tool to assess the road construction projects performance from technical, environmental, safety, and also socioeconomic viewpoint.

On the basis of performance predictions and projected structural performance that are conducted using feedback from the life-cycle analysis of previous projects, resource allocation can be optimized more reliably across limited resources and alternative road strengthening systems, providing technically sound solutions that are more economically attractive. The ability to perform accurate whole-life economic assessments associated with long-term infrastructure assets is important to sustainability.

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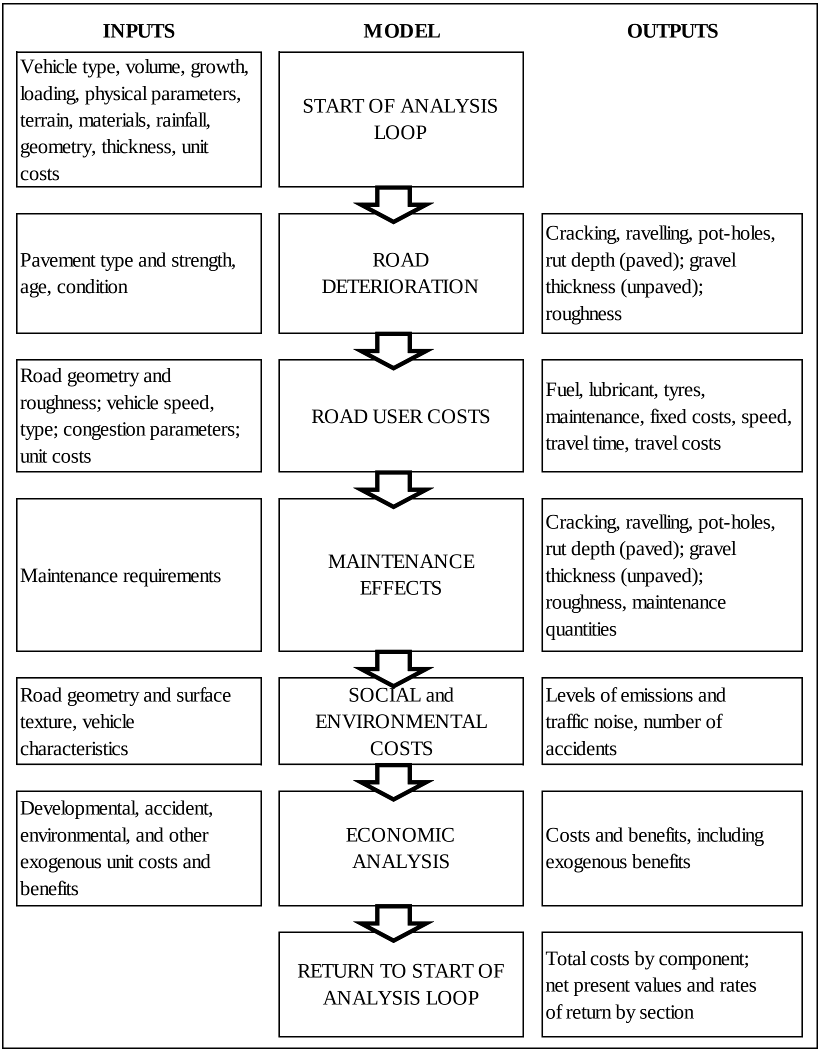
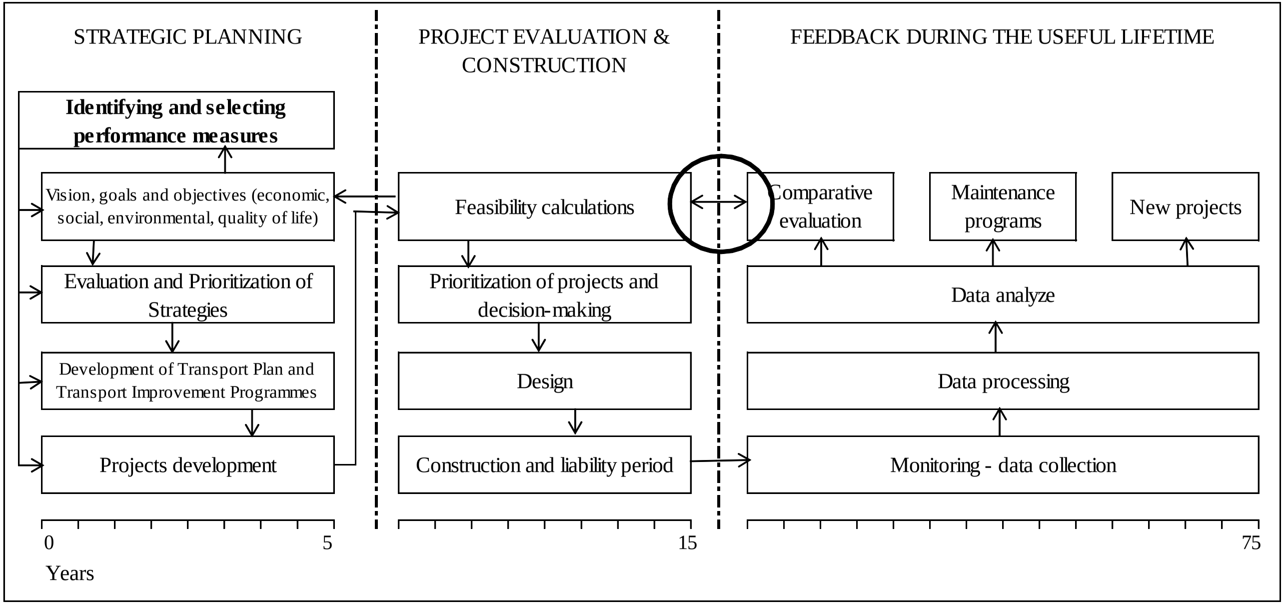
Appendix 1. Life-cycle analysis using HDM-IV



Source: Adapted from Kerali *et al*, 1998; Tsunokawa, 2010.

Appendix 2. Transportation planning framework using performance measurement system



Source: Adapted from Siggerud, 2002; A primer..., 2009; Kaare and Koppel, 2012.

Appendix 3. Possible performance indicators for road construction projects in Estonia (extract)

ACCESSIBILITY	MOBILITY
• Load restrictions, incl. bridge weight limits • Average trip length	• Traffic density and heavy traffic density • Delays, congestion, average travel speed, closures and detours
SOCIOECONOMIC ISSUES	**QUALITY OF LIFE**
• Economic costs of accidents • Economic costs of lost time	• Lost time due to congestion • Tonnes of pollution (or vehicle emissions) generated
ENVIRONMENTAL AND RESOURCE CONSERVATION	**ROAD TECHNICAL CONDITION**
• Overall mode split • Number of accidents involving hazardous waste	• Pavement condition indicators (distresses (longitudinal cracking, transversal cracking, alligator cracking, edge break, raveling, potholes), rut depth, skid resistance in summer and winter, strength indicators) • Bearing capacity (pavement, base, embankment) • Dustiness • Condition of drainage/water table • Temperature changes in bound layers • Unpaved roads indicators • State of bridges
OPERATIONAL EFFICIENCY	**SAFETY**
• Origin-destination travel times • Total travel times • Transport costs per tonne-kilometer • Maintenance cost per track-kilometer	• Traffic accidents and accident classes (fatal, injured, only vehicle) • Percentage of road mainline pavement (or bridges) rated good or better • Pavement surface temperature

Source: Compiled by authors using Australian..., 2011; Indicators..., 2011; Haas *et al*, 2009; Performance..., 2001; Performance..., 2006; Truu, 2012.

TULEMUSNÄITAJAD TEEHOIUINVESTEERINGUTE HINDAMISEL

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Teehoiule kulutatavad vahendid moodustavad olulise osa Eesti riigi- ja kohalikest eelarvetest, ulatudes 2010 a. 312 mln euroni (sh riiklikud investeeringud 215 mln eurot). Käesoleva artikli eesmärgiks on selgitada projektipõhiste tulemusnäitajate kasutamist investeerimisprojektide võrdleval hindamisel. Küsimuse selline püstitus on tingitud asjaolust, et Euroopa Liidu toetused struktuurivahenditest maanteevõrku uuel eelarveperioodil suhteliselt vähenevad eelkõige raudtee- ja meretranspordi kasuks ning senisest märksa suurema tähenduse omandab investeerimisprojektide järjestamine suurimat võimalikku sotsiaalset kasu silmas pidades. Kuna alustatud on Eesti transpordi arengukava koostamist aastateks 2014-2020, on autorite poolt esitatud seisukohtadel otsene väljund selle arengukava rakendusplaanidesse.

Transpordiplaneerimise protsess peab ideaalis toimuma kõiki huvigruppe kaasates, et täita rida ühiskonna seisukohalt olulisi eesmärke – ummikute vähendamine, parkimisprobleemi lahendamine, õhusaaste vähendamine, sundmobiilsuse vältimine jne. Samas on kirjanduses välja toodud rida kitsaskohti, mis ei sõltu planeeritavast piirkonnast ega transpordiliigist, nagu liiklusohutusnõuete eiramine, infrastruktuuri halb kvaliteet, negatiivse keskkonnamõju ignoreerimine jt. Sellest võib järeldada, et transpordi planeerimisel ei võeta piisavalt arvesse kõiki asjaolusid, mis võivad väljapakutavaid lahendusi mõjutada.

Projektipõhiste tulemusnäitajate valikul on oluline mõista transpordiplaneerimise ja transpordipoliitika olemust ja erinevusi. Esimene neist keskendub ühiskonna jaoks optimaalseima lahendi leidmisele, teist iseloomustab tugev seos õigusaktidega. Ühtlasi peavad transpordipoliitikas olema selgesti sõnastatud poliitika eesmärgid, mida on võimalik siduda tulemusnäitajate süsteemiga. Neid valitud näitajaid peab olema võimalik järjepidevalt ning automaatselt hinnata ja jälgida.

Investeeringud infrastruktuuri on transpordisektori tõhusa toimimise peamiseks eelduseks. Majanduspoliitika seisukohalt toetavad infrastruktuuriinvesteeringud selliste esmaste eesmärkide nagu majandus- ja regionaalareng, liikuvuse tagamine, ohutus, turvalisus ja jätkusuutlikkus, saavutamist. Teisalt on transpordi-investeeringute vastu suur avalik huvi, kuna neid finantseeritakse peamiselt üldiste või tarbimismaksude arvel.

Seega on oluline viia riiklike investeeringute juures ebatäpsete prognooside ja vigaste tehniliste lahenduste võimalus miinimumini. Et antud nõuet täita, tuleb investeeringute valiku protsessis arvestada juba lõppenud projektides selgunud kitsaskohtadega ning leida lahendused tehtud valearvestuste vältimiseks. Seetõttu on investeerimisprojektide valikul kriitilise tähtsusega asjaolu, kas ja millises ulatuses on nende väljatöötamisel arvestatud varasemate projektide järelhindamise tulemustega.

Infrastruktuuriinvesteeringuid iseloomustavad reeglina rajatud või renoveeritud taristu pikk eluiga, suured pöördumatud kulutused ning investeeringute tulemusena lisandunud mõjud ümbritsevale keskkonnale. Tänapäevased sotsiaalmajandusliku tasuvusanalüüsi meetodid ei piirdu ainult rahakäivetel põhinevate tasuvusnäitajate kasutamisega otsustusprotsessis, vaid annavad rahalise mõõtme ka transpordi välis-mõjudele.

Maailmapanga poolt on välja töötatud spetsiaalne metoodika teehoiuinvesteeringute tasuvuse hindamiseks, nn Maanteede Projekteerimise ja Hoolduse Standard (HDM), millest käesoleval ajal on paljudes riikides, sh Eestis, kasutusel versioon HDM-IV. Antud metoodikat kasutades teostatakse sotsiaalmajanduslikke tasuvusanalüüse investeerimisprojektide valikul ning selles on modelleeritud enamus transpordi-süsteemi kulukategooriaid – teekulud, kasutajakulud (sh tarbija ajakulu), liiklus-õnnetuste kulud, ummikukulud jne.

Teekulude arvutamisel võetakse mudelis esmalt arvesse rida tehnilisi parameetreid, nt tee pikkus ja sõidutee laius, tasasus, pöördenurk, pikikalle, katendi tüüp jne, kuid teisalt tuleb tee hooldusprogrammi koostamisel lähtuda ikkagi tee eeldatavast kasutusaktiivsusest. Prognoositava liiklussageduse põhjal on võimalik arvutada välja ka liiklusõnnetuste arv ning adekvaatsete ühikhindade olemasolul nendest tulenev kulu ühiskonnale. Arvutuste väljundiks on traditsioonilised tasuvusnäitajad (nüüdis-puhasväärtus, sisemine tasuvusnorm), mida võrreldakse olemasoleva situatsiooni (nn 0-stsenaarium) ja erinevate tehniliste lahenduste kaupa.

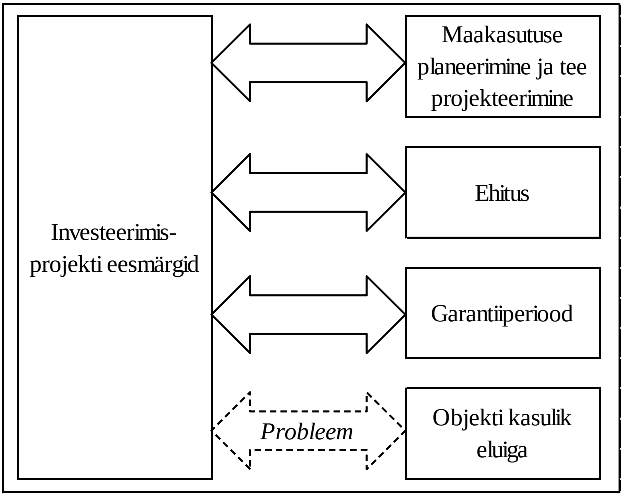
HDM-IV, aga ka mistahes teise lahenduse kasutamisel teehoiuprojektide prioriti-seerimiseks on oluline küsimus, kas arvutuste sisendina kasutatav informatsioon on usaldusväärne. Autorid on seisukohal, et usaldusväärse teabe kogumisel ei saa piirduda ainult projekti elluviimisel koguneva informatsiooniga, vaid teave peab hõlmama kogu rajatud objekti kasulikku eluiga. Seega peab pidevalt toimuma protsess, kus kogutakse, analüüsitakse ja sünteesitakse informatsiooni tee seisukorra ja kasutusaktiivsuse kohta, ning võrreldakse seda tee-ehitus- või teeremondiprojekti tasuvusarvutustes kasutatud eeldustega. Võrdluse tulemusi saab kasutada uute projektide tasuvusarvutuste koostamisel ja aluseks võetavate tehnoloogiate valikul.

Erialakirjanduse ja maailmapraktika analüüsist selgus, et kuni viimase ajani puudus ka sellistes kõrgeltarenenud riikides nagu USA, Kanada ja Suurbritannia selgelt kirjeldatud ja dokumenteeritud süsteem teehoiualase informatsiooni kogumiseks. Eelmise sajandi lõpul, käesoleva sajandi alguses viidi nende riikide, aga ka Maailmapanga ja OECD poolt läbi rida uuringuid, et leida lahendusi investeerimis-projektide valiku tõhustamiseks. Selgus, et kuigi transpordi, sh teehoiu eest vastu-tavad riigiasutused kogusid hulgaliselt asjakohast informatsiooni ja ka avaldasid selle, ei seostatud seda investeerimisprojektide otsustusprotsessiga ega seotud ka tulemusnäitajate süsteemiga.

Uuringute tulemusena välja töötatud tulemuslikkuse mõõtmise süsteemid erinevad riigiti/organisatsiooniti detailides, kuid hõlmavad reeglina järgmisi valdkondi – juurdepääs infrastruktuurile; liikuvus (liiklussagedus); transpordi sotsiaalmajanduslikud mõjud; mõjud inimeste elukvaliteedile; transpordi keskkonnamõjud ja ressursikasutus; tee ja teerajatiste tehniline seisukord; liiklusohutus; efektiivsus. Ühine joon nendele süsteemidele on see, et nad hõlmavad kogu teedevõrku, mida konkreetne asutus haldab.

Eestis kuulub teehoiu korraldamine riigimaanteedel Maanteeameti kompetentsi. Ka Eestis kogutakse hulgaliselt informatsiooni tee seisukorra, liiklussageduste ja –olude, liiklusõnnetuste, liiklejate liikluskäitumise jms kohta. Lisaks eelpoolmainitud HDM-IV-le on kasutusel teisi lahendusi, nt teekatete seisukorra hindamise süsteem EPMS.

Allolevalt jooniselt on näha, et ka Eestis, sarnaselt teiste riikide praeguseks osaliselt muutunud praktikale toimub tegeliku tulemuse ja investeerimisprojekti koostamisel kasutatud eelduste võrdlemine kuni tee või teerajatise garantiiperioodi lõpuni. Edasise teabekogumise käigus võimalikele hälvetele enam tähelepanu ei pöörata, mistõttu juba tekkinud vead võivad korduda tulevikus elluviidavates projektides.



Joonis. Tee-ehitusprojektide hindamise senine praktika Eestis.

Seega on tagasisidestamisel oluline osa investeerimisprojektide hindamisel teehoius. Antud asjaolu arvesse võttes esitasid autorid projektipõhiste tulemusnäitajate nimistu, mida rakendataks kogu tee või teerajatise kasuliku eluea vältel. Näitajate valikul on lähtutud maailma parimast praktikast, kusjuures erilist tähelepanu on pööratud tee seisukorra näitajatele ning arvesse on võetud Eesti klimaatilisi tingimusi. Autorid eeldasid, et näitajad on kas Maanteeameti olemasolevatest andmebaasidest kättesaadavad, või nende kogumise ja analüüsimise alustamine ei too kaasa olulisi täiendavaid kulutusi. Viimane osutub võimalikuks eelkõige tänu info- ja kommunikatsioonitehnoloogiate kiirele arengule. Autorid leiavad, et projektipõhiste tulemusnäitajate kasutamisel on võimalik oluliselt tõhusamalt kasutada teehoiu piiratud ressursse, valides Eesti tingimustesse tehniliselt kõige sobivamad ja vastupidavamad lahendused.