THE ROLE OF PERFORMANCE MEASUREMENT IN FORMING ESTONIAN NATIONAL TRANSPORTATION POLICY

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ABSTRACT

Transportation policy seeks to guide the development of more sustainable transportation systems and mobility patterns, which in turn should promote economic growth and an improvement in the quality of life. The government agency responsible for the management of an infrastructure project must be able to accurately scope out the initial required investment, and future financial requirements for the maintenance of the given infrastructure throughout its targeted lifespan. Strategies for developing and maintaining mobility within transportation networks have been launched in many countries, however, less attention has been given to how the measure network deterioration and to analyse investments associated with maintaining infrastructure in peak condition. This paper focuses on indicators of performance measurement and monitoring frameworks applied in the road transportation sector and how indicators can help evaluate the effectiveness of transportation policy. Use of performance measurement cannot in and of itself guarantee the development of more effective policies, but government should be able to, based on more detailed and accurate data, make more informed decisions. More accurate and detail data can reduce subjectivity and the number of unknowns in decision making and allow for the setting of more targeted and realistic objectives. Policy targets need to be realistic and measurable. Performance indicators can be measured through Intelligent Transport Systems (ITS) that use censors, lasers and magnetic loops. This paper focuses also on the importance of feedback from performance measurement in the process of policy-making, in raising the reliability of resource allocations across limited resources and introduces examples of new intelligent technologies for data acquisition. The above-mentioned issues are addressed based in the example of Estonia.

Keywords: performance measurement, Key Performance Indicators, road network, transportation policy

INTRODUCTION

Transport infrastructure is a vital social and economic asset; it structures space and determines mobility. It influences trade flows as well as industrial and residence locations. Its construction and maintenance absorb significant resources and its highly visible and public nature raises important policy concerns especially on its environmental effects. Decisions on infrastructure have impacts that last for decades, even centuries. Transport infrastructure planning and financing are controversial political topics at national and in European Union countries increasingly at international level (Short and Knopp, 2005).

There is a significant role of performance measurement outcomes in strategic processes carried out by the transportation agencies. They are listed as following:

- resource allocation;
- monitoring programs, projects and/or whole network;
- strategic planning;
- reporting to the elected officials;
- reporting to the internal management of transport authorities;
- reporting to citizens (also *via* media).

One of the lessons that many countries and institutions (including Estonian Road Administration – authors remark) have learned is the need for modesty. The difficulty of developing and using performance information, as exemplified by these challenges, should be recognized by all. Further, the role of performance information is one of informing decisions not determining them. There is a real need to educate the users of such information on how to use the information and on its possible interpretations and limitations (Aldridge *et al*, 2009).

The importance of rational use of objective performance information is especially pertinent for budget decision-makers. There may be a temptation to use evidence of poorly performing programs but to ignore or question performance information about well-performing ones. Misuse here will send quite strong messages. Performance information will normally not be comprehensive, will contain some uncertainty; its role should always be seen as informing. Therefore wise evaluation criteria and evaluation audits are needed to support the decision making process.

Performance Measurement Systems (PMS) with accurate data are needed both when transportation agency's face reducing of budgets or increases in funding. They can be used effectively to establish the need for increased funding with policy makers and the public. Performance measures provide valuable information to communicate with policy-makers on transportation funding needs. They provide an important mechanism to communicate planning and programming results to decision makers and the public.

The PMS should also help to addressing the overall need or rationale for why any decisions are made and to be a tool to help the agency to do the best possible job given the circumstances, resources and constraints, consistent with the overall mandate. Performance measurement is needed for the network to function as a whole. Performance measurement should be an on-going activity for road network agency. The use of performance measurement information will help set agreed-upon performance goals, allocate and prioritize resources, inform road network operators to either confirm or change current policy directions to meet those goals, and finally, report on the success of meeting the goals set. In order to make performance measurement a useful tool for improvement the gathered knowledge, must be carefully tied to the agency's mission and strategic goals regarding the development of road networks (Smith, 1993).

STATE-OF-THE-ART

Several countries, incl. Estonia 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. Goals are essentially the way of communicating a regional or national vision of how the transport system should contribute to the social, economic and environmental facets of the community.
The Estonian national transit infrastructure is generally well established. The biggest economical challenge is a good road network, which in Estonia is the area that constantly needs development and improvement. The total length of national roads in Estonia as of January 1, 2013 was approximately 16,000 km, i.e. 28% of the total length of the Estonian road network, which was 58,768 km. The length of E-roads (European roads accepted and systematized into international road network by UNECE) in Estonia is 995 km (Annual report…, 2013).

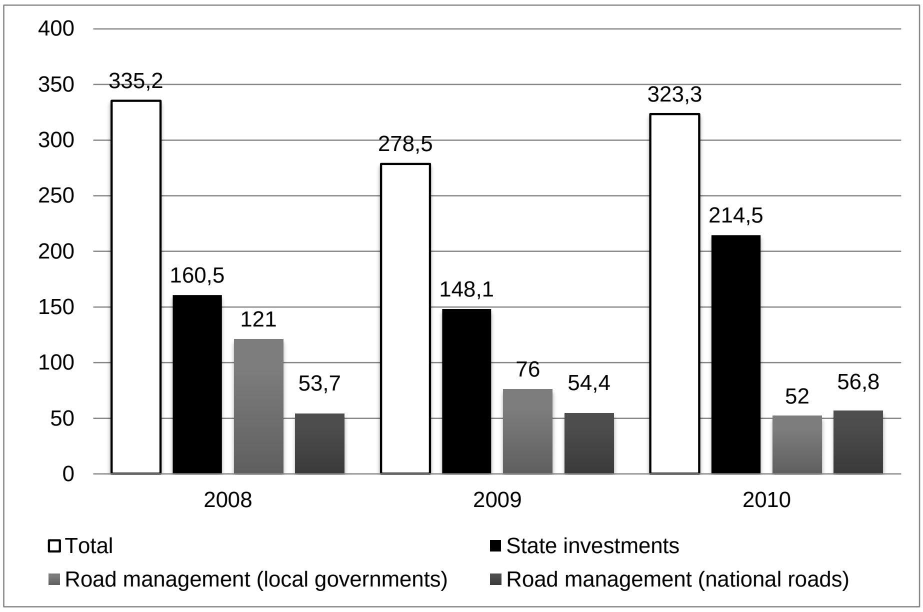

Figure 1 – Expenditures for road management in Estonia 2008-2010, mil. euros (Annual report…, 2013)

The Estonian Road Administration (ERA) is a government agency operating under the auspices of the Ministry of Economic Affairs and Communications (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.

The rapid economic growth in the beginning of this century led to transportation shortages and congestion problems and increased the demand for road quality improvement. With the help of European Union (EU) funds the Estonian government has given high priority to road development, investing particularly in the construction of high-quality roads. The amount assigned for road infrastructure development for the period 2008-2013 was 737 mil. euros. The annual budget of the ERA is approximately 300 mil. euros which constitutes approximately 30% of state investments into the Estonian real sector (see Figure 1).

The challenge of the Estonian Government is to ensure the sustainability of infrastructure with limited financial resources. Currently a new Transport Development Plan (TDP) is being created by the MoEC. The primary objective of national TDP is to operate and maintain a pleasant network for all customers to confidently know they will be able to get to their destinations comfortably, safely and quickly at all times of the day or night. There is constant pressure on the government and ERA to justify the use of public funds on infrastructure. It cannot be done without a PMS with measurable Key Performance Indicators (KPI-s) that gives feedback on the sustainability, operation and safety of the network.

In Estonia, the developed road construction projects are monitored and supervised very strictly 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 profitability calculations and durability of materials and comparing estimated repair span to the actual need during the lifecycle (see Figure 2).

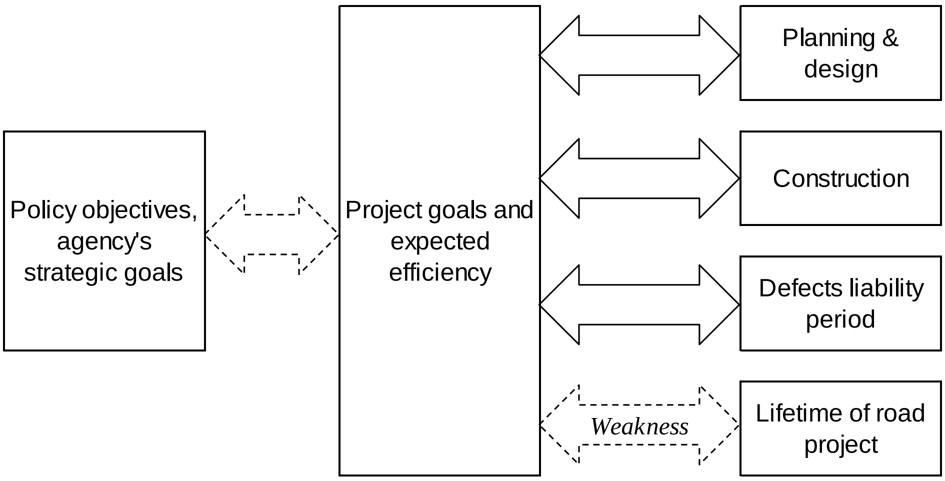

Figure 2 – Current practice of road construction projects evaluation in Estonia (Kaare and Koppel, 2012)

Therefore the authors point out the following flaws in Estonian road management. First numerous databases (Pavement Management System, Traffic Accidents Database, Weather Information System, Road Register, Smart Road Database) collect information about important indicators, but they are not connected and getting the necessary data requires substantial effort and time. Secondly, national investment planning methods have a number of defects, the most serious is a lack of transparency. Third, appraisal of projects is still inconsistent and weak. Strategic appraisal is in its infancy. *Ex ante* appraisal is often biased and *ex post* analysis rarely takes place. Fourth, planning process and decision making are not always transparently linked to the transportation policy. Given the increasing complexity and length of these processes, could be of great value to society.

This paper is based on larger scale research in Tallinn University of Technology to develop performance measurement guidelines for Estonian road network (Kõrbe, Kuhi and Koppel, 2012; Kaare, Kuhi and Koppel, 2012a, 2012b and 2013; Kaare and Koppel, 2012a and 2012b), to eliminate the abovementioned flaws in Estonian road management system and to create a system that supports the achieving of goals set in National TDP.

ROLE OF PERFORMANCE MEASUREMENT IN TRANSPORTATION POLICY FORMATION PROCESS

The concept of efficient road management has been introduced in the past two decades as the "process of maintaining and improving the existing road network to enable its continued use by traffic efficiently and safely, normally in a manner that is effective and environmentally sensitive; a process that is attempting to optimize the overall performance of the road network over time". Road management involves a number of tools that include (Karlaftis and Kepaptsoglou, 2012):

1. Policy Formulation: Definition of standards and policies for the road sector,
2. Monitoring: Knowledge of the network extent, conditions and traffic characteristics,
3. Needs Assessment: Determination of required expenditures for management and operations,
4. Capital Budgeting: Appraisal and ranking of investment options,
5. Project Programming: Programming of maintenance and improvement projects,
6. Monitoring Maintenance: Monitoring of maintenance projects, and
7. Monitoring Performance: Obtaining performance measures for operations.

Road management policies are an important part of national transportation policy. Developing transportation policy 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 travelling public and freight operators through a proactive public participation process (Rodrigue, Comtois and Slack, 2013; Litman, 2011) This co-operation and input from all interest groups results in developing and implementing a regional or state transportation policy (see Figure 3).

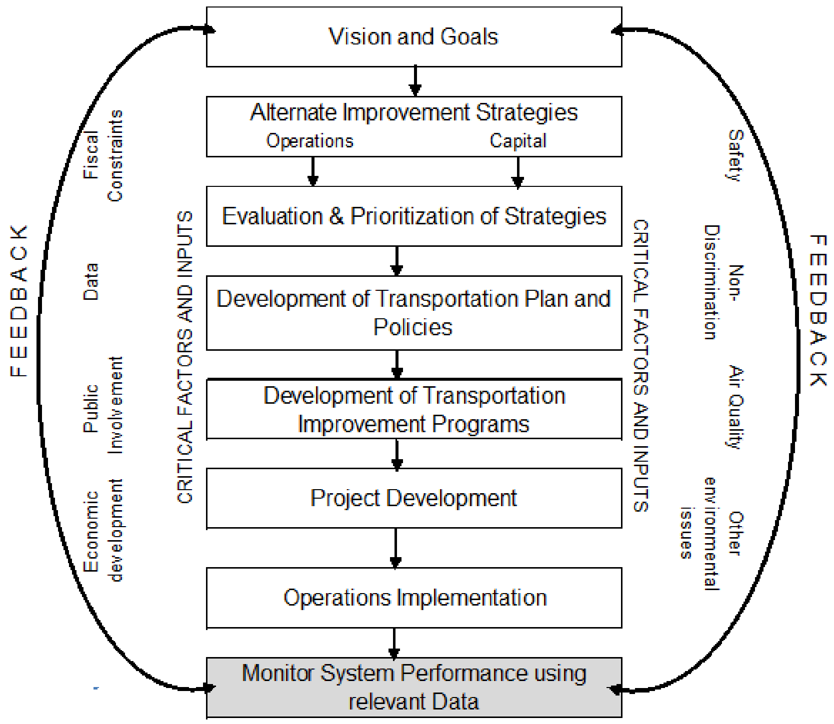

Figure 3 – The transportation policy-making and implementation process (The Transportation…, 2007)

Monitoring and feedback are critical components of policy-making. They include the on-going 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. Therefore, performance measurement is fundamental to ensure that transportation policy and funding achieved desired policy outcomes. Because of that the measurement of performance in the public sector become increasingly important in recent years and it is now commonplace for transport organisations, and local and national governments, to publish performance goals for service supply and quality (A Primer…, 2012).

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 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).

ITS AND PERFORMANCE MEASUREMENT

Our vastly developing environment of Information and Communications Technologies with numerous applications should be more involved and implemented into the transportation planning process. We have started using mobile positioning and map applications. On the other hand, advantages of innovative technologies in the field of ITS like participatory sensing, accelerometers, different sensor networks, Radio Frequency Identification (RFID) need to be emphasized and implemented as data collection tools. New applications and cloud computing gives opportunities for instant integration of different groups of society into the planning process and avoiding exclusion of valuable input. Besides planning purposes the information can be exploited also for traffic management, road maintenance, monitoring of dangerous goods, feedback and state of existing network and in the process of shaping the transportation policy.

Different countries, regions or road agencies have developed their PMS 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. A key part of current approach is the development of performance measures that rely on ITS infrastructure for monitoring performance. The next two paragraphs describe in detail two conceptual ITS solutions that support performance measurement both in operational and strategic level.

Sensor-based systems

Authors have studied RFID tags with sensory functions because it is considered that the RFID tag can detect some conditions of structures and transfer its information through external reader. With this in mind was developed a system (see Figure 4) to monitor the condition of road structure and establish the impact of water content and temperature change to road deterioration and with the use of RFID tags with sensory functions.

The device may be located in the moving vehicle or placed stationary on the road side. The RFID reading on motion will add certain requirements on the tag and reader antenna orientation, but at the same time reduces cost. Having many metering points with stationary readers will cost more than few, but often by-passing vehicles with the Interrogator on board (Dziadak, Sommerville and Kumar, 2008; Lee et al, 2009).

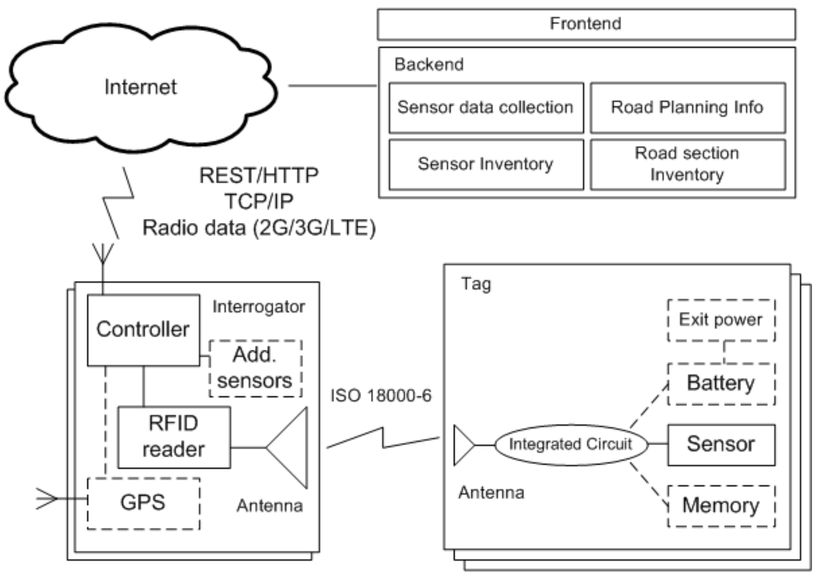

Figure 4 – Architecture of the system for monitoring the condition of road structures with the use of RFID tags (Kõrbe, Koppel and Kuhi, 2012)

Interrogator processes and enriches the raw sensor tag data. It consists of a RFID reader together with an antenna and data processing system. It may contain the Global Positioning

System (GPS) module to add the location coordinates to the sensor reading event to allow reporting in deviations of stored data and field information. Interrogator contains additionally sensors for reading the air temperature, relative humidity, and speed of the Interrogator when in motion.

Because of the limited funds available for the construction of new roads and also for road maintenance, it is essential that effective enforcement of the axle load regulations be carried out throughout countries, limiting access of heavy vehicles on roads not suitably designed and constructed. 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.

Comparing the data from distinct sensors and locations enables identification of correlations between as-constructed properties of asphalt concrete in construction databases and field performance of pavements in pavement management systems to quantify the link between material quality, traffic flow and performance. By comparing traffic data and wearing of several lanes gives for data users feedback about the impact of traffic load and tire type on that particular asphalt mix. Further on with more test fields the performance of different asphalt mixtures can be evaluated. A conceptual model (see Figure 5) was developed that enables to analyse and predict more precisely future pavement deterioration in highways based on road utilization. By adding climate data to the traffic model, prediction of the approximate timeline for probable maintenance needs of a flexible pavement will become possible.

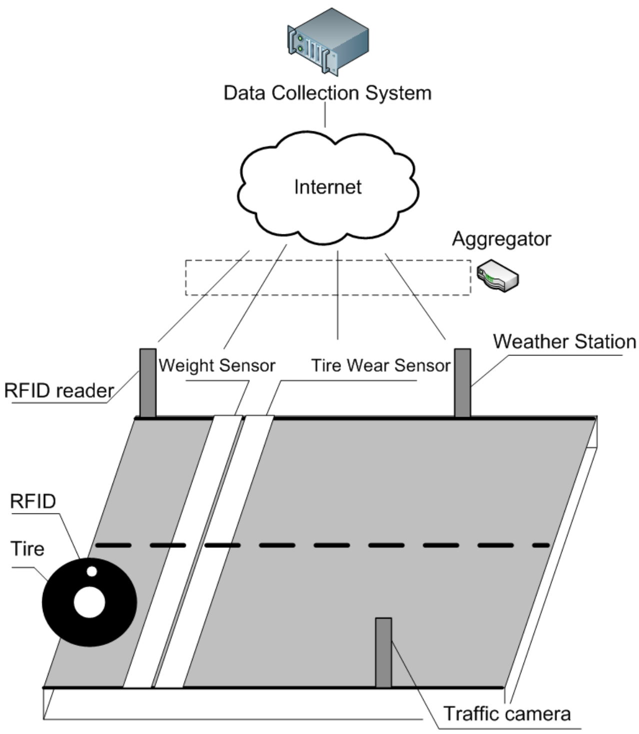

Figure 5 – Architecture for the system for monitoring tire and pavement interaction (Kaare, Kuhi and Koppel, 2012b)

System architecture and data collection system will be such that information will be provided to consumers dynamically as they request it. Sample usage scenario in Estonia may be a

driver starting to drive from Tallinn to Tartu (two biggest cities in Estonia, distance between towns approximately 185 km) requesting road condition information from the system – the car will subscribe to the road condition information on the route, receiving it directly and incrementally in real time from the server as the car proceeds on the route. Similarly the police may request information on traffic loads on different roads or locations receiving it from the sensors in the location.
Other potential beneficiaries are, for example:

- Internal and external security forces (police, criminal police, customs, border guard authorities, defence forces),
- Road maintenance and construction authorities,
- Transportation companies (see Figure 6).

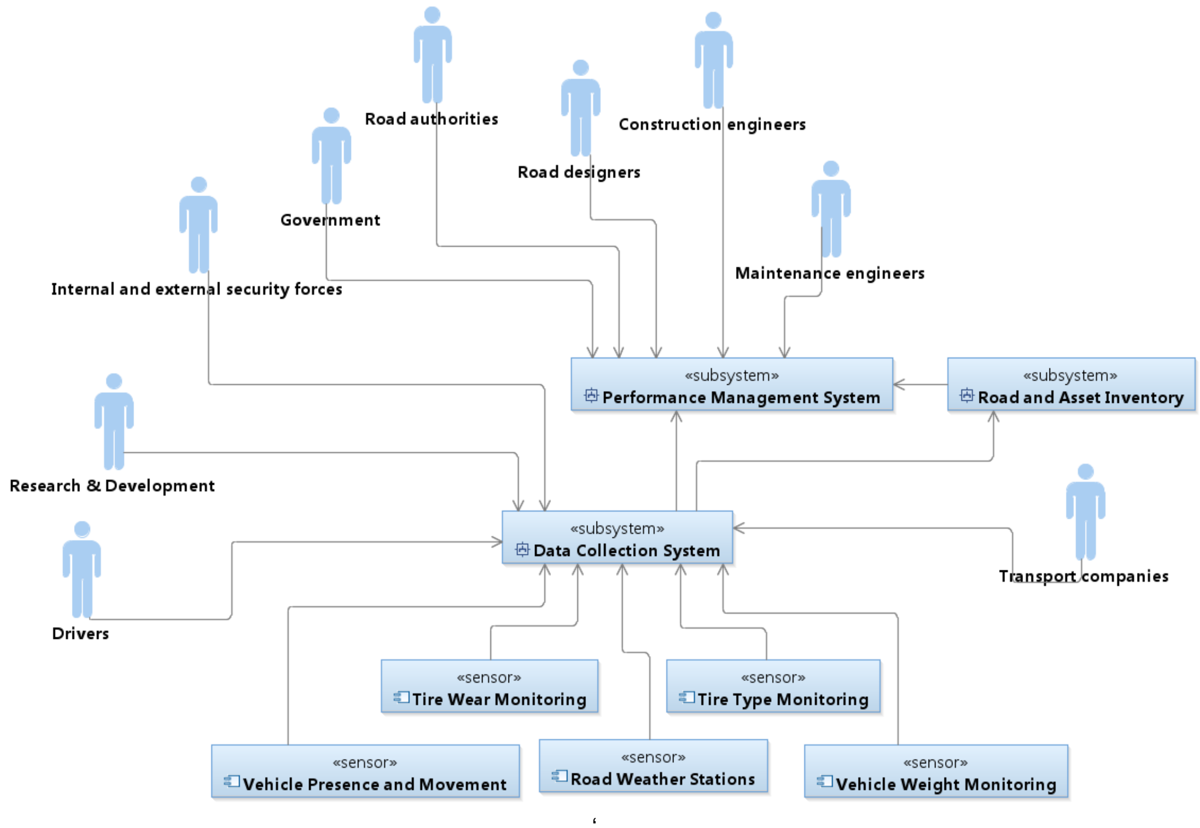

Figure 6 – Data consumers and sensor-based PMS (Kaare, Koppel and Kuhi, 2012b)

Sensors feed the collection system with constant flow of values depending on the traffic load distribution in time domain on the measured road sections. During peak hours the data flow amount grows equivalently with traffic volume. The backend data collection system hardware and communication channels must be dimensioned accordingly to accept the sensor data. The integration with other Information Management Systems must be taken into account when designing the architecture of the data collection system. It is constructed in a way that supports effortless integration with any number of third party systems in the south-bound interface.

Participatory sensing

Participatory Sensing is an approach to data collection and interpretation in which individuals, acting alone or in groups, use their personal mobile devices and web services to systematically exchange information. Today billions of people carry mobile phones. These ubiquitous devices are increasingly capable of capturing, classifying and transmitting image, acoustic, location and other data, interactively or autonomously. Given the right architecture, they could act as sensor nodes and location-aware data collection instruments. The idea of a wireless sensor network is not new; we are already able to integrate sensing, computation and connectivity in low-power devices and embed networks of them in the physical world to collect data.

Through physical proximity to what they study, multi-scale operation and adaptive, autonomous observation, embedded sensor networks allow the observation of previously unobservable phenomena. Instead of being in the hands of a central observer, these sensors are always on and under their owners' control. Leveraging them effectively and conscientiously will require models that prioritize user participation in sensing. Researchers, policymakers and the public can use data to understand and persuade; higher quality data tend to generate more significant action and better understanding (Burke *et al*, 2006).

Android Operating System based smartphone hardware platform contains several types of sensors that can be categorized as motion, environmental and position sensors, including triple-axis accelerometer, and GPS to capture geographical coordinates and vehicle speed (see Figure 7). Other smartphone hardware platforms have similar functionality available. The accelerometer measures the acceleration in m/s^2 that is applied to a device on all three physical axes (x, y, and z), including the force of gravity. Applying high-pass filter to the accelerator values linearizes the values and gives the acceleration value excluding force of gravity.

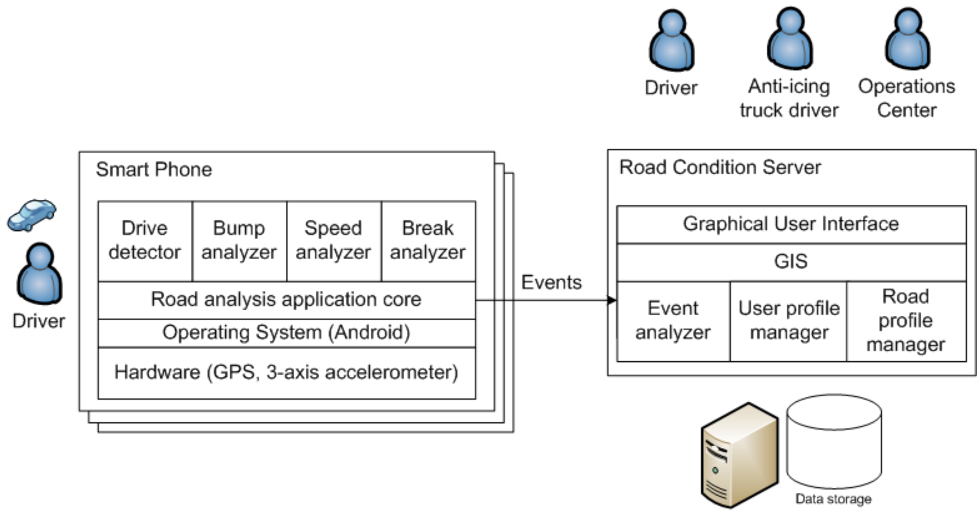

Figure 7 – High-level architecture of the system for detection of road winter condition (Kaare, Koppel and Kuhi, 2013)

Example scenario for participatory sensing in the road data acquisition process is described as follows. The process is divided into the six main steps: 1) sensor data acquisition, 2) feature extraction, 3) classification, 4) anomaly detection, 5) profile calculation and blacklisting, and 6) information distribution. Steps 1-3 are executed in the smartphone application, steps 4-6 in server side (see Figure 8).

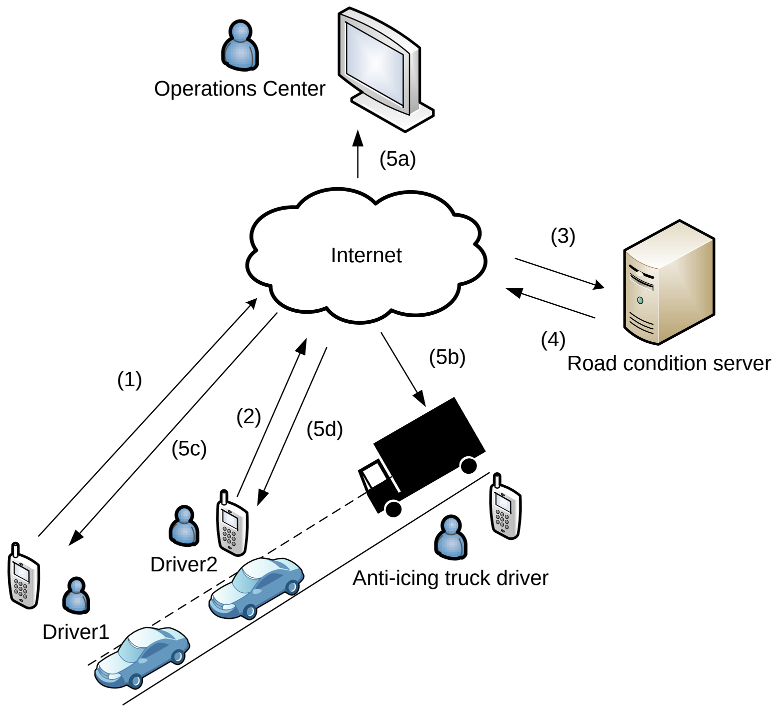

Figure 8 – Example scenario based on the participatory sensing (Kaare, Koppel and Kuhi, 2013)

The accelerator three-dimensional input signal is merged into one acceleration magnitude by taking the Euclidean magnitude of the three individual values. It can be done since the bump detection algorithm does not require distinction of directional accelerations (Das *et al*, 2010). The vehicle location and speed is obtained using GPS sensor. Geographic location is sensed at a particular time. A location consists of latitude and longitude, a Coordinated Universal Time (UTC) timestamp, and optionally information on altitude, speed, and bearing.
GPS accuracy is important in pothole detection they need to be properly located and multiple detections combined to report a single pothole. In case of maintenance planning solutions the accuracy is not so important, it is important to know where are the areas in need of maintenance and which are in good condition. The acceleration magnitude and GPS signal obtained by the phone is noisy. The noise comes from two primary sources: irregular sampling rates and discrete physical sampling of a continuous function. In parallel with the acceleration magnitude and location data the vehicle speed is captured and analysed.
Dynamically sized sliding window is applied to the acquired data and different features are extracted:

- vehicle speed – minimum, maximum and arithmetic average values in the time window;

- acceleration magnitude – fundamental frequencies, arithmetic average, minimum, maximum value, standard deviation, mean, variance;
- acceleration values for each axis – fundamental frequencies, arithmetic average, minimum, maximum value; standard deviation, mean, variance.

The features are classified and published as events from the smartphone to the server when enough evidence is found using Naïve Bayes classifier. On server side another more resource intensive classification algorithm will continue evaluation of the events. The real time event collection feed (steps 1…3 in Figure 8) is evaluated on server side based on the event class, location, driver profile, weather forecast and road weather station readings, collection time, and closest data in time when the road section was clean. Another sliding time window of an event is dynamic and based on the amount of events in time interval on that particular road. Data processing anomalies are detected during the process and logged for learning purposes.

For example: first driver smartphone application classifies an event. The event data together with metadata is passed on through Internet (using mobile data communication technology) to the backend Road Condition Server (step 1). The second driver detects an event approximately in the same location (step 2) and passes the data to server. The real time event collection feed (step 3) is evaluated on server side based on the event class, location, driver profile, weather forecast and road weather station readings, and collection time. The event is sent out from the server (step 4) and distributed to interested parties (step 5). The time window of an event is dynamic and based on the amount of events in hour on that particular road. After successful evaluation of the series of events, the road profile (and the map) is updated with the combined event information. Also the user profile will be updated with higher trustworthiness rank.

A key to the system success is making it possible to have communication between any information provider and information consumer without the need for complex integration work. Access to the system is controlled via security levels – an information consumer is only able to consume the data on the level to which it has been provided access, e.g. some users may only have access to aggregated and pre-processed data, while other users have access to data at the sensor level. The data access mechanisms stay the same, no matter what level access or to what data is requested and granted.

PMS FOR ESTONIA

Road PMS is planned as a system for all of Estonia. It gathers data in real time from different sources to produce useful information. At any time managers can have a uniform, comprehensive assessment of road network performance. Traffic engineers can base their operational decisions on knowledge of the current status and planners can determine whether congestion bottlenecks can be alleviated by improving operations or by minor capital improvements. Travellers can obtain the current shortest route and travel time estimates. Researchers can validate their theory and calibrate simulation models and design engineers receive feedback what solutions are sustainable in what conditions. PMS is a low-cost system that uses the ERA network for data acquisition and is easy to deploy and maintain.

PMS applications are accessed over the World Wide Web; custom applications can work directly with the PMS database. The PMS architecture and use in transportation policy-making are described below.

PMS metrics

As stated before, transportation policy needs to be performance-driven, directly linked to a set of clearly articulated goals and accountable for results (Performance Driven…, 2009). When goals have succeeded, they have acted as a catalyst and focus for delivery of desired outcomes by all the relevant actors. However, some goals have clearly failed to inspire positive outcomes.

The reasons for this are varied but two key themes have emerged. First, sector-specific outcome targets drive expenditure to achieve these goals whether or not it represents good value for money. Second, the metric chosen for the indicator of performance is of crucial importance. There is an understandable tendency to concentrate on metrics that are already measured even though these metrics may lead to unwanted management actions (Marsden and Bonsall, 2006).

To improve performance for the benefit of users, it is critical to implement processes that enable the assessment of operations. Performance assessment methods must be both reliable and credible and must serve as a means of changing how things are done. It is thus advantageous to establish specific performance indicators, methods of analysis and evaluation, as well as structured and quantified quality plans. Some of the major reasons for adopting performance include:

- accountability: performance measurement provides a means of determining whether resources are being allocated to the priority needs;

- efficiency: performance measurement focuses actions and resources on outputs and the process of delivery;

- effectiveness: performance measurement provides a link between ultimate outcomes of policy decisions and the more immediate actions of transportation agencies. It provides a means to evaluate how well we are achieving our goals;

- communications: performance measurement provides better information to customers and stakeholders on progress being made toward desired goals and objectives;

- progress: performance measurement allows periodic refinement of programs and service.

In Estonia there have been discussions to link regional transport objectives and national objectives with performance metrics from projects and strategies, as well as with the accountability of individual senior roles in the responsible government organisations. These links have not been working due to insufficient traffic management and operations data, an undefined framework for developing metrics around stated objectives, and the poor linkage between strategy development and performance measures. The authors recommend ERA a range of categories of measures suited for PMS, for example:

- accessibility and mobility (examples: average travel time from origin to destination, average trip length, lost time or delay due to congestion, level of service ratios),
- quality of life (examples: tonnes of emissions, customer perception of safety and urban quality, average number of hours spent travelling, % population exposed to noise above certain threshold),
- environmental and resource consumption (examples: number of days in air quality noncompliance, fuel consumption per vehicle- or passenger-km),
- safety (example: number of accidents per passenger- or vehicle-km),
- operating efficiency (system and organisational),
- transport network system technical preservation (examples: percentage of roads and bridges below standard condition, remaining service life of assets, maintenance unit costs, international roughness index (IRI) for pavement).

An extract from performance metrics by consumer categories, indicators and data sources is presented in Table I.

Table I – Extract from determination of ERA's performance metrics (Kaare, Koppel and Kuhi, 2012a)

Stakeholder	Aggregate KPI-s	KPI-s	Variables	Data Source
Road maintenance department	Road technical condition	Average IRI per km of track	IRI	Pavement Management System
			Road section length	Road register
	Infrastructure utilization	Average load per km of track	Rolling stock weight	Weight sensors
			Road section length	Road register
Traffic management department	Traffic density	Average traffic density by lines	Traffic modal split	Traffic counters
			Road sections length	Road register
Traffic safety department	Traffic safety	Traffic accidents per km of track	Traffic accidents and accident classes	Traffic Accident Database
			Road sections length	Road register

There is a need for Estonia to invest further in ITS infrastructure and analysis tools to support the further development of PMS. Efficient automated processes for routine reporting are recommended, in particular ones which are able to fuse data from different sources.

PMS architecture

Performance data does not tell us why the outcome occurred. Performance systems need to be designed in a way that they do not only gather, store and provide data outcomes (score), but they also need to have built into them opportunities to analyse the details of performance and steps to seek explanations for the outcome data such systems produce (Galvin and McGlynn, 2003).

Performance indicator database collects all the measurements and stores them until required for the KPI reporting functionality. When the data is no longer needed, it will be removed from the live data schema and archived. Also the preparation, cleansing and consolidation of the data into different Performance Indicators are done there.

KPI-s are calculated based on the data in the Performance Indicator Database and calculation formulas. KPI formulas may be deterministic or probabilistic. Different authors (Ismail *et al*, 2011; Li, 2005) have shown the applicability of Probabilistic Graphical Models (Markov Networks, Bayesian Belief Networks) in road performance index calculation. KPI-s may have multiple (aggregation) levels based on user needs. KPI-s are displayed in the User Interface showing the current situation or as historical trend. Drilldown from KPI value until the specific performance indicator or sensor value is needed to understand the root causes of different situations (see Figure 9). Corrective actions will be taken in response the KPI shows deviation from the norm. The architecture enables systematic investigation of the root cause of the non-conformities to prevent their occurrence, recurrence or minimize the effect on the road performance.

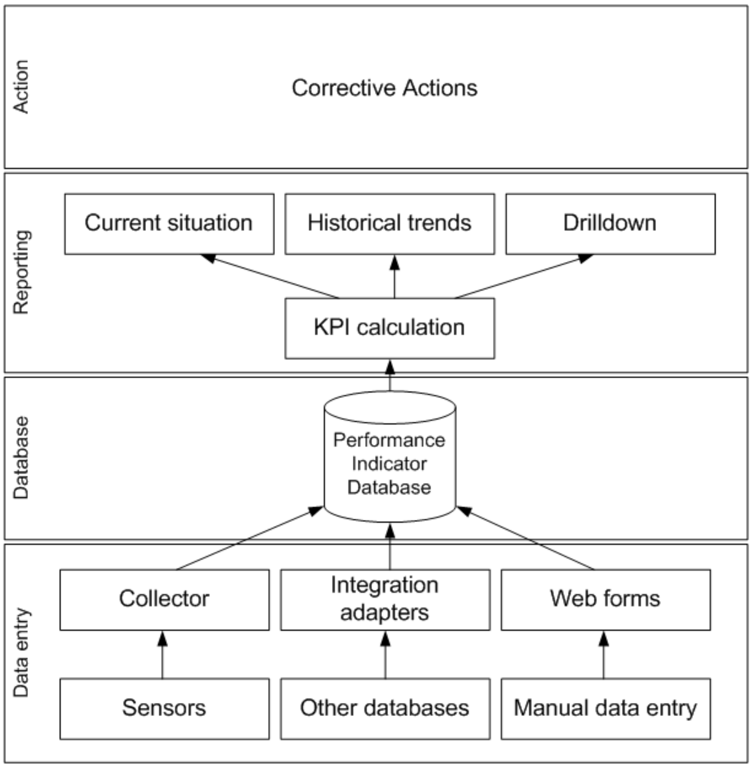

Figure 9 – PMS architecture (Kaare, Koppel and Kuhi, 2012a)

Access control to the data collection system is controlled via security levels – an information consumer is only able to consume the data on the level to which it has been provided access, e.g. some users may only have access to aggregate and pre-processed data, while other users have access to data at the sensor level. The data access mechanisms stay the same, no matter what level access or to what data is requested and granted.

Linkages between PMS and Transportation Policy

The ability to perform accurate whole-life economic assessments associated with long-term infrastructure assets is important to sustainability. Strategies and policies for sustainable mobility in transport have, in recent years, been launched in many countries, however, the questions arise how the sustainability of transport systems and policies can in fact be measured, and how these measurements can be used in transport planning. The decisions transport planning are based on objective data from PMS, subjective data consisting of values, opinions and biases and political guidelines or priorities. Figure 10 describes the linkage between Performance measurement how the formed decisions through implementation over different time horizons affect the road agency operational level, strategic level and finally economic development, quality of life and environmental quality.

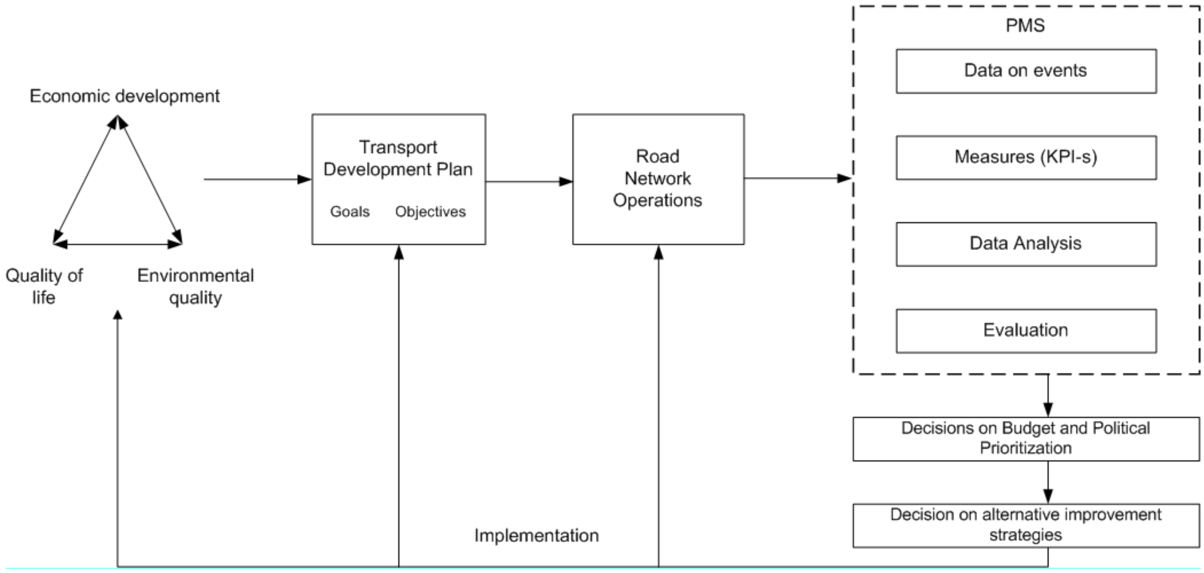

Figure 10 – Data needs framework with connections to transportation policy-making (based on Lomax, 2008)

Figures 10 and 11 emphasize the importance of evaluation in performance measurement. Making decisions based only on outcomes from the obtained data may lead to failure and dysfunctional consequences therefore evaluation criteria should be established and evaluation instrument carried out where necessary. In road network performance measurement, evaluation should complement and support the system. Evaluation tools can remedy a number of the shortcomings of performance measurement when applied in performance management and also contribute to research-based policy development.

The future effectiveness of the updated Estonian TDP will depend on how well national goals are linked with performance measurement and the integration of strategy development and project implementation. Therefore, it is important that we consider the overall context of long-term planning decisions and life cycle approach. Integrated PMS to transportation policy-making suggested by authors gives a detailed and analysed input for the government budget planning.

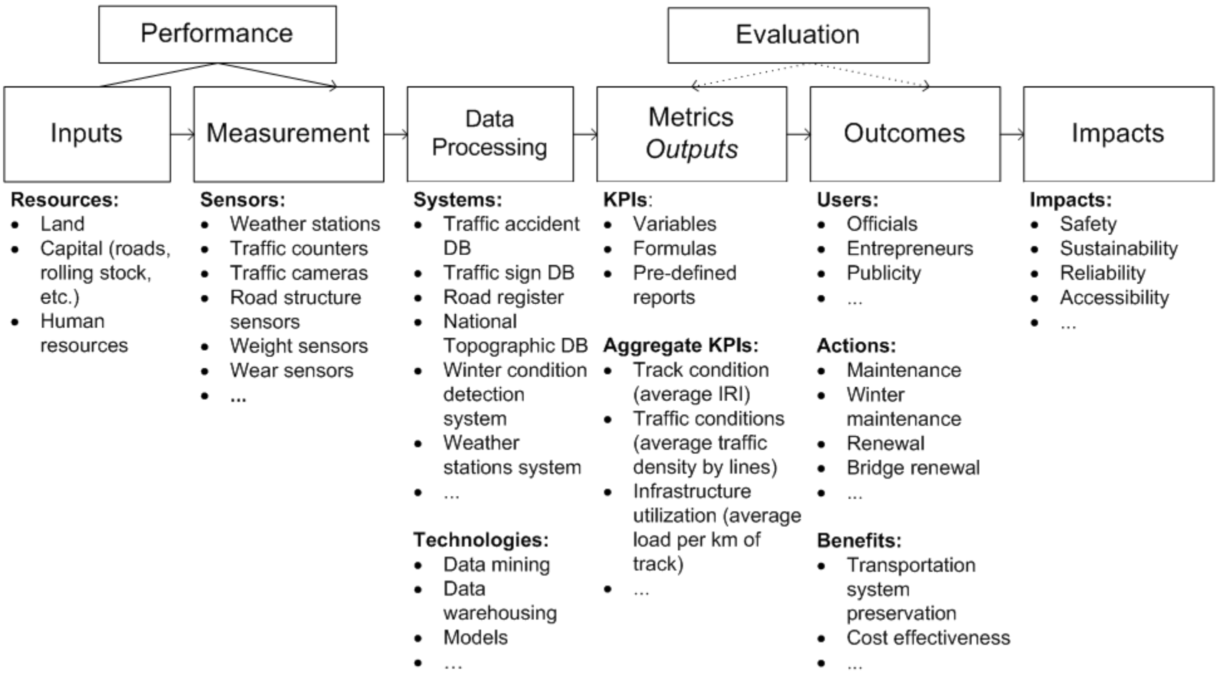

Figure 11 – General Framework of the Road Performance Measurement Process (Kaare, Koppel and Kuhi, 2012a)

The role of further research is to define transport network data collection options, identify current gaps in ITS coverage, and scoping the required investment in infrastructure and analysis tools. The recommendations for developing x-road between databases should be also made. A feedback mechanism is required so that if there are objectives that can’t be measured can be reviewed and in necessary cases restatement of the objectives is carried out.

CONCLUSIONS

ERA as well as others can better integrate the goals set with Transportation Policy into their planning, programming, and project development activities through performance measures. Performance measures provide quantified evidence of the consequences of a decision or action. By translating data and statistics into a succinct and consistent format, performance measures offer an efficient way to provide information to decision-makers. Transportation performance measures predict, evaluate, and monitor the degree to which the transportation system accomplishes adopted public objectives. They can be applied at all stages of transportation decision-making.

Performance monitoring enables ERA to observe trends in key indicators and assess the progress it is making toward its policy goals and objectives. Developing and using performance measures is not necessarily easy, every country needs to identify the most appropriate measures according to the goals set in their policy. The use of objective, measurable and policy outcome related indicators in many cases requires collecting new data or assembling and processing data collected by other agencies or even introducing new technologies. The current trends in innovative technologies in ITS give road authorities means to gather objective information and cloud computing offers new possibilities of cross platform databases.

Transportation agencies have started to report performance measures see their value and have come to expect regular reporting of measures and a more explicit linkage between the measures and government policy decisions. Transportation agency staff and stakeholders can then engage in a much richer conversation about the trade-offs among policy and investment decisions and the best opportunities for a country to reach its transportation planning goals.

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