Development of a Road Asset Management System in Kazakhstan

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ABSTRACT: The paper describes the development of a custom Road Asset Management System (RAMS), that will take care of about 23’500 km of roads that make the Kazakhstan main network of roads (Republican roads), that also includes 6 international corridors. The system has two main roles, (1) organizing the asset information (road cadaster or “road passport” according to the Kazakh standard) in a modern digital database and (2) managing the maintenance of the network, optimizing through economic analysis the budget allocation for maintenance works. The system development takes also care of organizing the data collection procedures for both roles, that will be done using automated devices installed on mobile laboratories. The system will also use data from other sources, such as the growing Intelligent Transport System (ITS) equipment (mainly weather stations, cameras, Weigh In Motion (WIM) devices and traffic counters for the purposes of this system). The system is organized as a web based service and it is accessible through any internet connected device, offering the operators the possibility to browse the database or update it in any place with an internet connection available. One of the key element of the system is its ability to make analysis and forecasts: the system is developed to measure periodically condition data across all the network, to have a clear understanding and control on the status of the roads. This module uses Highway Development and Management Model (HDM-4) to make pavement maintenance analysis and optimization of resources. The system will start its operation with the first complete data collection, that will be calibrated over the years by the repetition of condition analysis, allowing to improve reliability and quality of analysis forecasts. The system will also serve for other analysis, such as the control of Asset Value, analysis on the effect of new road projects over the network.

1. INTRODUCTION

Road networks may be still considered, as a whole, one of the more expensive assets for each Country to develop and maintain; nevertheless, there is usually not enough attention to the management and optimization of the expenditures related to it.

The reason for this comes from multiple factors, including the higher attention to the development of the road networks (opposed to rational management and maintenance) and to the overall complexity of the technical and economic evaluation.

In the past 40 years, several attempts to rationalize the management of such complex systems (asset management) has been started, but only in the last 20 years, with the widespread availability of cheap and powerful computing tools allowed to efficiently manage the problem.

2. ASSET MANAGEMENT SYSTEMS

Roads assets include a wide range of items, whose most valuable is usually the road pavement, followed by the artificial structures and tunnels (depending on terrain characteristics): these assets are managed through dedicated systems named, according to the core item Pavement Management Systems (PMS), Bridge Management Systems (BMS) and Tunnel Management Systems (TMS).

Modern road network systems are getting more and more complex, in particular higher categories highways that nowadays include many Intelligent Transport System (ITS) systems, as well as road furniture (e.g. roadside safety devices and vertical road signs) that require dedicated and continuous monitoring and maintenance. The management of such complex system require a new holistic approach, that should take into account all the parts of the road: these new systems go under the name of Global Management Systems (GMS) (Loprencipe et al., 2012, Bonin et al., 2007).

3. INFORMATION ON KAZAKHSTAN

Kazakhstan became an independent republic after the fall of Soviet Union, in 1991; over the last 25 years the Country progressed steadily reaching the upper-middle income status.

Kazakhstan has a wide territory (2’724’900 sq.km) and a very small density (6.5 people/sq.km with a population of less than 18 million people); this is mostly due to its location and climatic conditions.

Kazakhstan is located in the middle of Central Asia, just South of Siberia; the climate is continental but, due to its size, it may be further divided into 4 climatic zones. In most of its Central-North and North-Eastern regions it suffers from very cold winters, where the soil may be continuously frozen for more than 4 months.

3.1 *Road network*

Kazakhstan, due to its position in the Central Asia and to its mostly flat land, it is a natural location for international routes, such as the corridors that connects South (Kyrgyzstan, Uzbekistan and others through these) and North (Russian Federation) and mostly East (China) and West (towards Europe through Russian Federation).

For this reason, the World Bank funded a large project on the “Western Europe-Western China international transit corridor (CAREC[1] 1B and 6B)”, worth more than US$ 2 Billion (in the references). This large project started in 2009 and mainly targets the construction or improvement of these international corridors, but also includes a specific fund for the improvement of Public Administration and Management procedures, including the development of a Road Asset Management System for the Republican Roads of Kazakhstan.

Figure 1 Kazakhstan main road network and neighbour Countries

The Republican road network consists of about 23’500 km of roads and is the main network of roads in the Country; it includes (i) international corridors (ii) main national road network (iii) the toll road network.

Most (91.5%) of the Republican roads have an Asphalt concrete pavement, although about 8.1% are gravel or unpaved roads (see Table 1 below).

Table 1 Kazakhstan Republican Road network pavement type.

Pavement type	km	Network share, %
Asphalt concrete Warm Mixed Asphalt (WMA) or Hot Mixed Asphalt (HMA)	10’001	42.6%
Cold Mixed Asphalt (CMA)	11’491	48.9%
Cement concrete	97	0.4%
Gravel and cold asphalt (transition)	1’797	7.6%
Unpaved	107	0.5%
TOTAL	23'493	100%

3.2 *Review of the current situation – road organizations*

Kazakhstan is still moving in its transition from the old centrally planned economy to the market economy: while many transformations have already been made, these are not yet fully consolidated and many changes in the road organizations, management procedures and standards are still in progress.

The Road Asset Management System is a modern tool that may serve to support the transition, not necessarily toward the market economy, but certainly to a more modern and efficient management.

The road sector is now controlled by a governmental authority, the Committee of Roads (CoR) that is under the Ministry of Investment and Development (MID); the CoR is surrounded by some other publicly owned road organizations:

- Road manager

  National Company (NC) KazAutoZhol is a Joint Stock Company (JSC) that has been established recently (resolution 79/2013/CoR and Government Resolution of December 26, 2013 № 1409).

  The CoR realizes some of its main objectives through KazAutoZhol, such as (i) realization of a state policy on development of a network of highways and (ii) maintenance of roads and their structure for ensuring uninterrupted and safe traffic.
- Maintenance operator

  Republican State Enterprise (RSE) KazakhAvtoDor is the road organization that, through its local regional branches, conducts routine repair, maintenance and landscaping of the republican road network. The Committee for Roads acts as a client for such works through KazAutoZhol.

  Wider scope repairs are usually performed through bidding processes opened to private con-

[1] CAREC: Central Asia Regional Economic Program (http://www.carecprogram.org/), a partnership of central Asian Countries and multilateral institutions (funds and investment banks) to promote development through cooperation.

tractors, although (Oblast) branches of KazakhAvtoDor may participate, as a rule, for republican roads sectors that belong to their region.

- Research, technical and scientific advisory
  JSC KazDorNII is the Kazakh road research institute, whose stocks are owned by MID.
  The most general direction of the institute's scientific activity is enhancement of roads operation reliability, such as (i) investigating road safety conditions in order to improve normative base of roads designing and reconstruction and (ii) investigating opportunities to use traditional materials as well as local and new materials, including composite and industrial waste materials for construction of roads.
  KazDorNII has also a full set of testing equipment for road materials as well as special testing vehicles (Mobile Laboratories, ML) for the data collection of roads.

3.3 Review of the current situation – road standards and practice

The current Kazakh standards are developed on the basis of the Soviet Union standards, continuously updated and coordinated with the other Countries of the Commonwealth of Independent States (CSI).
Regarding the management of road assets, 3 standards are mostly relevant to the process:

- PR RK 218-28-03 (currently updating) on Certification of roads (Road Passport), that includes technical details for the definition of the "rad passport". The contents of this "road passport" is completely defined within the standard and represents the official inventory of road assets, which goes under the name of "road cadastre" in other Countries.
- PR RK 218-27-14 (currently updating) on Diagnostics of road assets, that includes the standards and procedures for the testing of roads assets, mainly road pavement and road structures (bridges and culverts).
- PR RK 218-19-01 on Spring and Autumns survey, that describes the procedures for the semi-annual road condition assessment and the procedures for the calculation of the synthetic Global Road Quality Score.

Other standards define specific tasks and topics, such as traffic measurements, material specifications and testing, quality control.

3.4 Current maintenance and repairs estimates

It is important to notice how the terminology slightly differs in Kazakhstan from the international common practice: this may lead to inconsistencies and misunderstandings in the analysis and reports when international consultants operate in the Country, however the terminology in use is rather clear and consistent if it is well exposed and clarified.

Under the term "maintenance", in the Kazakh practice, are included: winter maintenance, landscaping (mowing, trimming of vegetation), drainage cleaning and the current maintenance (other small maintenances excluding road repair).

The repairs on road pavement or structures are divided into:

- "current repairs", with smaller scope, including patching potholes, crack sealing, repair of edge breaks, etc. (performed by public maintenance company KazakhAvtoDor);
- "mid-term repairs", with intermediate scope, including any pavement overlay – that is not common practice in Kazakhstan – or recycle/reconstruction of top layer of pavements, under 50mm (performed by public or private contractor);
- "major repairs" or "reconstruction", with the wider scope: the definition differs mainly on being the "reconstruction" a set of road pavement works that involve an upgrade of road category.

The current practice for road maintenance is driven by the "spring and autumn survey" standard, that is a road maintenance assessment that is performed twice a year, using the autumn survey results as a basis for the budget estimate for the maintenance and repairs.

There are, although, several shortcomings in the current practice:

1. Subjective assessment: the autumn and spring surveys on the road conditions are carried on by a commission that includes inspectors from road manager organization, road works/repair organization and Police; the reports are based on visual assessment and expert's judgement of the inspectors rather than quantitative, objective, measurements.
2. Cost estimate without prediction of pavement deterioration: he current method, regarding the road pavement maintenance, is essentially a cost estimate of the repair works, based on the previously detailed visual assessment results. Such cost estimate, (a) being the assessment made during the autumn and (b) without the use of a road pavement deterioration model, always results in out of date cost estimates, when they are applied: the repair works, after the discussion and approval process inside the Authority, usually start more than 18 months after the assessment.
3. Optimization (i): reports are further used to calculate, by a set of formulas that "weighs" the asset conditions to calculate a global quality index, used to assign a "score" to each road; such score is used to prioritize the budget and to represent the status to the Authorities (ministries) involved in the budget allocation for the next years. The

synthetic single score including all the maintenance needs may result in unclear identification of the issues.

4. Optimization (ii): the current cost estimate process does not use any optimization strategy and this is made worse by the fact that the budget allocation are usually lower than the necessary need; the latter, that is likely in any Country, without a budget reallocation strategy through optimization, causes maintenance inefficiencies and may carry also to an overall lower care of the cost estimate process (there is a general lack of confidence/interest into making it accurate, since no one will take advantage of it).
5. New technologies: this lacking process of assessment/analysis/optimization/control makes it very difficult to take advantage of new technologies, either on the materials, machinery, management and execution of works.

4. DEVELOPMENT OF THE KAZAKH ROAD ASSET MANAGEMENT SYSTEM (RAMS)

Some earlier projects identified the need to support reorganization of the road sector in Kazakhstan with the development of a modern Road Asset Management System (RAMS).

The main goal of the project described in this paper is to address the shortcomings identified in the current process for road maintenance management in Kazakhstan.

This is largely supported by international organizations and funding agency, because it has been identified as a key element to provide an assessment on the real conditions of roads, to evaluate the best strategies to solve the issues and to optimize the available budget allocated for the purpose of improving road transport.

The RAMS main achievements will be:

- The creation of a digital inventory, through a structured database, of data regarding the Republican road network, including asset data, conditional data (mainly regarding road pavement), information regarding road maintenance expenditures and other data.
- The establishment of improved methodologies for the collection of data (road asset inventory and road pavement condition), through the use of advanced testing vehicles (mobile laboratories), whose availability in the Country, already sufficient to start the activities, will be further extended through a parallel project.
- The establishment of a new budget estimate and optimization procedure, through the use of HDM-4 analysis. This will also allow the possibility to run iterative budget analysis, to expand the sensibility on the optimal budget allocation by considering different scenarios.
- The new HDM-4 based analysis allows also to integrate the maintenance analysis with other projects, such as new roads or reconstruction: specific longer term analysis will allow to tune the budget allocated for maintenance with future new expansion of the network.

Following this, it is to remark that a complete Road Asset Management System is not only the software and equipment used to collect, store, analyse and deliver information and results, but it is, indeed, extended to the whole process of managing the Road Asset, including, to a higher level, the road sector organization and, to a more practical level, all the rules (laws, technical standards, operating methodologies) and the experience of all the people involved.

The completion of such complex system will take some years and will need adjustments and adaptation, as well as continuous support from the government, the stakeholders and the operators.

The transition towards the completion of the system and the reform of the supporting standards and maintenance approaches will be done in 3 stages:

1. First stage: foundation/development
   includes the development of the core system (database, software and Information Technology (IT) architecture), the arrangement of equipment for data collection and definition of methodologies and operating procedures. During this phase it should be also detailed the strategic plan for the further implementation of the system, that should also include the support to Performance Based Maintenance Contracts.
2. The second stage: initialization
   It is foreseen an initial minimum 3/5-year time frame for this, that will focus on completing the reference data collection, the adjustment of standards, methodologies and procedures for the system operations. This will be done through the feedback from the actual use of the system. During this stage the system management will be maintained within the Ministry, with the direct involvement of the Road Manager, to allow a more comfortable transition to the new procedures.
3. The third stage: system complete (fully operational)
   This starts when (i) the system is ready enough to complete every year the cycle of data collection-analysis-budget forecast for all the Republican road network predicting reliably the road maintenance expenditures and (ii) the new performance standards and all the related procedures are set properly and all the stakeholders are ready to take full advantage of the new procedures.

The readiness in stage 3 represents the maturity, intended as the capacity to provide reliable forecasts, as well as allowing further improvements through research.

The improvements include the whole process, starting from the general rules and standards, the correct setup of the road sector management process, the data collection and analysis procedures, and also to take full advantage of any new technology.

4.1 RAMS database

The RAMS database is the core of the system, as it stores all the data in a structured digital database. This, itself, represents a great step forward for any administration that is still based on traditional practices, often relying on paper documents and reports.

This situation is also common, yet, in many Countries. The typical situation is the "incomplete transition" to modern, fully digital systems: although data are exchanged daily through the offices using email or by exchanging data files, the data are usually not structured or stored, in the final revision, in some easy to reuse and reanalyse format, such as any database format.

Too often the final elaboration of the data are stored in a PDF format or as a text documents (such as Microsoft Word), making it very unpractical for any reuse.

Kazakhstan has a dedicated organization and some State protocols to enhance the use of digital technologies that goes under the name "Digital Kazakhstan 2020"; part of this program, that is now in an advanced status, is the transfer of all the Governmental Servers and Systems to a modern Cloud based infrastructure, that will assure the best level of security for data, maintenance standards for hardware and availability (in terms of fast communication channels and redundancy/failure tolerance).

The Kazakhstan RAMS, that is a natural candidate to became a Governmental system, also uses this cloud based architecture, with a dedicated MS SQL server for the DBMS (Data Base Management System). This assures the availability of data (accessible through dedicated Virtual Private Network (VPN) channels or through Internet, depending on the level of access) and a reliable and powerful platform for the analysis needs.

The database is structured according to the data needed, that is divided into 3 main categories:

1. Asset data (road passport data in the local standard).
2. Road condition data (mainly through the mobile testing vehicles)
3. Other data, including those transferred from other systems (such as traffic data, weather condition data, etc.) and data input by road organizations (operations data – road open/closed/roadworks, emergency data – road accidents/severe weather conditions, management data – e.g. actual expenditure data for roadworks and maintenance).

Data needed for the yearly analysis through HDM-4 (that comes from all the 3 categories) is a subset of all the available data fields (in particular regarding 1) asset data and 2) road condition data): the local technical standards foresees a wider group of data, that is also included in the RAMS database and may be useful for additional detailed analysis.

4.2 RAMS workflow

The general workflow of an Asset Management system, shown in Figure 2, has been used as a reference for the development of Kazakhstan RAMS; it shows clearly that there are several cycles to control the implementation and the efficiency of the system, that shall be carefully enforced and managed.

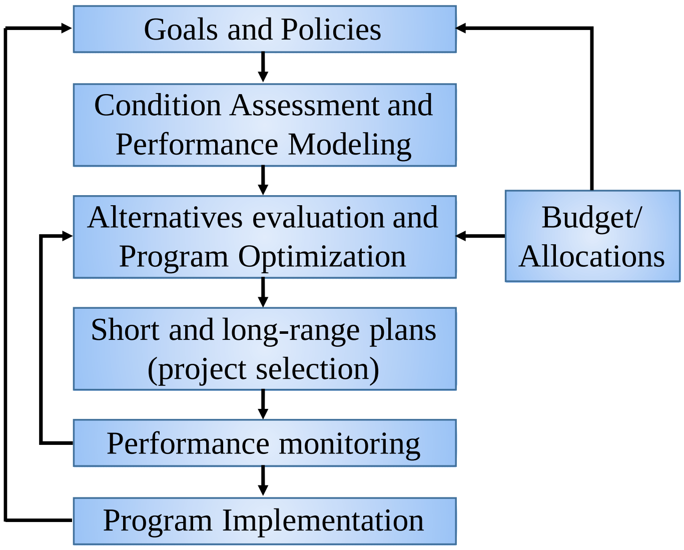

Figure 2 - General workflow of an Asset Management system (FHWA Asset Management Primer, 1999)

In addition to the items in the diagram, it is important to pursue the continuous improvement of the system, that includes:

- calibration of the analysis tool (HDM-4), through the availability of feedback data from the implementation of the maintenance works and comparison with the previous predictions;
- refinement in data collection procedures, that may be enhanced from availability of new equipment and technologies, but it is mainly due to the increased experience of the operators, the data quality assurance procedures and the better understanding of the road network;
- critical analysis of the whole process performance is necessary, to identify shortcomings and inefficiencies; this may be done through an internal evaluation of the system performance, with the improvement of regulatory documents and standards and through an expert's external supervision and dedicated research projects.

4.3 Data collection

Although the system is flexible to store data for different needs, it is important to clarify that the main scope of this Project, the development of the Kazakh RAMS, is to assure the possibility to store information and execute analysis for the strategic budget allocation.

For this purpose, the Ministry of Investment and Development (MID) of the Republic of Kazakhstan (RoK) invested in the purchase of highly specialized mobile testing vehicles for its National Research Institute for Roads (KazDorNII) and for the OblZhollaboratory road organization.

KazDorNII has 2 mobile testing devices for this purpose:

- A fully equipped Multi Function Vehicle (MFV®) with Falling Weight Deflectometer (FWD), Ground Penetrating Radar (GPR), IRI and rutting measurement systems, cameras, Global Positioning System (GPS) and fully automated Laser Cracking Measurement System (LCMS®), manufactured from Dynatest®.
- A vehicle with cameras and GPS, with specific software dedicated to asset recognition and positioning (Road Passport data collection), manufactured from NPO Region®.

KazDorNII usually serves as the reference scientific institute for the RoK, including the preparation of technical standard and advisory for technical and quality control issues. Their vehicles are currently used regularly for the quality control of the newly built roads. KazDorNII will likely be directly involved in the data collection of RAMS and as technical and scientific advisor for the RAMS management.

The OblZhollaboratories are the regional local units directly controlled by the MID, consisting in 14 Oblast (regional) units, plus 2 newly established for the main cities of Kazakhstan and their metropolitan region, Astana and Almaty.

OblZhollaboratories will be the main source of pavement condition data, due to the large availability of equipment and to its dislocation in the Country: the MID is completing the fleet of 16 mobile testing vehicles (one per each branch), including the refurbishment of some previously owned vehicles.

These vehicles are fully equipped with Falling Weight Deflectometer (FWD), Ground Penetrating Radar (GPR), International Roughness Index (IRI) and rutting measurement systems, cameras, GPS and a semi-automated pavement defect measurement system.

The data will be collected during the end of summer or in autumn, before the winter snow; it is foreseen that, given the availability of vehicles, the surveys will be repeated every year during the initial phase of RAMS operation. This will assure a repeated feedback from the roads and the improvement of the analysis prediction accuracy. When the system will be mature enough, in terms of road condition prediction accuracy, it will be possible to reduce the frequency of surveys.

Survey data, after initial processing with on board equipment and software, will be transferred (stored) to the RAMS database for further processing.

The data processing is performed by trained operators and, currently, is greatly affected by the recognition of asset data and from the analysis of the pavement defects, that are not fully automated. Additional statistic strategies (such as those described in Krawczyk B., Szydło A, 2013) are adopted to reduce the amount of surveyed area (subsample) to be processed; this approach is also confirmed by other pavement distress methods (such as the Pavement Condition Index (PCI) survey methodology described in the ASTM-D6433). This approach will be further improved through specific research projects, when data will be available, and improved based on the availability of new software to assist the image recognition process.

Before the data will be fully published in the RAMS, therefore made available to the users and for the analysis, it will be performed a quality assurance procedure.

Since the main data available through the use of the mobile testing vehicles are those regarding the pavement condition and considering that the input data for the analysis tool (HDM-4) also includes other data, it is necessary also to provide them.

HDM-4 does not allow a detailed analysis of assets like artificial structures (bridges, culverts, retaining walls, tunnels etc.), drainage and technological systems (such as Intelligent Transportation System (ITS) devices), so the conditional data regarding these asset categories is collected using other methods, mainly through specific surveys and through the analysis of the reports form the road manager (KazAvtoZhol) and the road maintenance road organization (KazakhAvtoDor). It is possible that the RAMS will be further expanded with additional modules dedicated to these asset categories (Bridge and Systems in particular).

The drainage conditions, from the engineering point of view, are particularly important in some areas, because the flat terrain and the thawing of winter snow and ice causes big problems, with persistent floodings and soil softening issues.

The other main categories that have to be taken into account are:

- climate data: this has to be assessed and monitored periodically, as it is not necessary to track the continuous temperature changes for the analysis, but the Country has severe climate conditions, with hot summers and extreme winters, resulting in high annual excursion (may result in much more than 100°C if measured on the road surface, close to 90°C as standard air tempera-

ture, (see KazHydroMet.kz) and daily excursions (typical around 20°C as air temperature).
- Traffic data and vehicle fleet composition: this is one key parameter for any pavement analysis; this is currently measured using traditional methods, but there is an increasing number of ITS devices that will allow continuous monitoring of traffic and axle loading data (trough Weigh In Motion (WIM) ITS devices): data from the continuous monitoring will allow better understanding of the specific loading conditions, that shall be performed as a separate, analysis before the input in HDM-4.

4.4 Analysis

The Performance modelling and Alternative evaluation shown in Figure 2 are performed in the Kazakh RAMS through HDM-4.

HDM-4 (Highway Development and Management Tools collectively referred to as HDM-4), is the last revision of the Highway Design and Maintenance Standards Model (HDM), developed by the World Bank's Transportation Department for the analysis, appraisal and optimization/prioritization of road management and investment alternatives. HDM-4 is currently distributed and updated by HDMGlobal, an international consortium of academic and consultancy.

The software includes a Pavement Management System (PMS) based on a Pavement deterioration model (engineering module) and an Economic model, which are used to perform an integrated analysis.

The pavement performance models used in HDM-4 are based on a deterministic approach (se details in Watanatada et al., 1987; ISOHDM, 1995a,b).

The input parameters include, traffic, climate conditions, vehicle fleet consistency, road geometry data, safety information (accident rates) and details on the road pavement, that is the main engineering item. The pavement is detailed through its structural and construction characteristics (layer's thicknesses), conditional data (roughness (in terms of IRI), cracks, potholes, edge breaks, etc.) and surface characteristics (friction and texture depth).

The analysis consists in a two integrated subanalysis:
- an evaluation of the pavement performance, predicting its deterioration over time, with or without the application of maintenance strategies
- an economic analysis, performed through the evaluation of the Vehicle Operating Costs (VOC).

With this approach, it is possible to consider the effects on the users, rather than the sole agency cost and asset value.

The agency costs, essentially represented in the following Figure 3 as Road Work Costs (RWC) may be added to the User's Cost (UC, or VOC) to calculate the Total Road Transport Cost and select the best option.

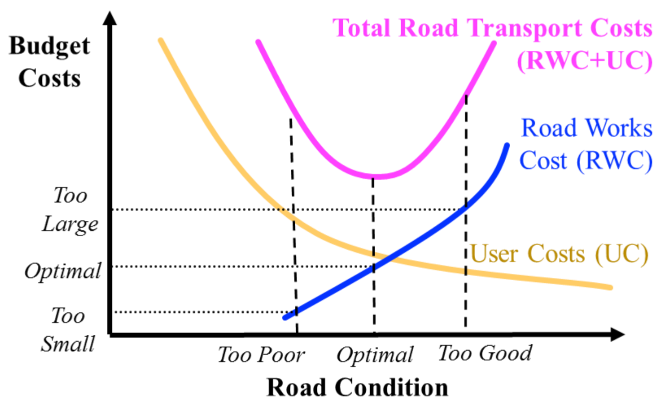

Figure 3 – Total cost, Road User's Cost and Road Works Cost

This tool will greatly enhance the analysis capabilities: in the current maintenance evaluation process, the budget allocation decision is based on the Cost Estimates calculated using the data collected using by mean of the visual assessment method described before; the current process, also, is unable to predict the pavement condition over time, therefore the budget allocations are decided on the basis of conditional data that are usually more than 1 year old (including 2 winter seasons) when the maintenance and repair works actually start.

Table 2 - Strategic, network, and project-level decisions (Zimmerman et al., 2011 and FHWA, 1999).

Decision Level	Decision Maker	Types of Decisions/Activities
Strategic	Legislator Commissioner Chief Engineer Council Member	Performance targets Funding allocations Pavement preservation strategy
Network (Tactical)	Asset Manager Pavement Management Engineer District Engineer	Project and treatment recommendations for a multi-year plan Funding needed to achieve performance targets Consequences of different investment strategies
Project (Operational)	Design Engineer Construction Engineer Materials Engineer Operations Engineer	Maintenance activities for current funding year Pavement rehabilitation thickness design Material type selection Life cycle costing

The HDM-4 allows the execution of project level analysis, road work programming under constrained budgets, and for strategic planning of long term network performance and expenditure needs. It is designed to be used as a decision support tool within a road management system.

This allows to serve Strategic and Network (tactical) decision levels, according to the definition described in the previous Table 2. This will allow a direct involvement in the analysis of the high level decision makers (usually Ministries) and mid-high level decision makers (typically the road management agency, KazAvtoZhol in RoK).

The analysis, after its completion, validation and acceptance, it is loaded into the RAMS database and made available to the authorized users.

4.5 Reporting and information to stakeholders

A very important function of the RAMS is the possibility to provide information to the stakeholders and to the road users, with specific tools and contents.

The system, through its data base core, may directly provide data, through reports (predefined or custom made), queries and through a GIS interface.

The data are provided to each user category on the basis of the user's needs and according to the RAMS manager authorization.

The higher level of authorization is granted to the Authorities and to the system administrators.

Reports are usually targeted to specific needs, including periodic reports for official purposes, evaluation of performance, verification.

Queries may be used to perform specific data analysis, including specific asset verification; the large amount of structured data will allow research projects, that are encouraged to further improve the system.

Direct browsing of data may be performed on the raw data (tables, data fields) or through the GIS mapping tool. This will also allow further development of the system, by allowing the professional road operators to browse the system on the road through mobile devices.

The GIS mapping tool is also the main medium of data publishing to the road users, the population. The data will be prepared through the main GIS tool within the RAMS, then the data will be published on an additional dedicated service (web server) on the basis of public mapping services (such as Google maps or Yandex maps). This will allow the integration of proprietary data (such as a synthetic 3 level pavement condition index or the information on the road service – road open/closed/with reduced lanes) with publicly available data through an interface familiar to users.

5. CONCLUSIONS

The development of a new Road Asset Management System is a complex task, that involves the knowledge of the state of the art for the equipment and procedures, as well as the understanding of the stakeholders' needs.

It is very important to understand the current procedure in use and to be able to make the system "useful" to all the involved players, to make its use really fruitful.

It is, indeed, really important to communicate the system capabilities and needs, to involve all the stakeholders to use it for their everyday duties and, therefore, continuously improving it.

The biggest advantages of the use of the RAMS in the RoK will be the availability of a structured, fast, always available source of data for the road assets and the possibility to produce more reliable, detailed and useful analysis, including the optimization of budget allocations, that are nowadays not possible.

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