# ASSET AND PAVEMENT MANAGEMENT FOR RURAL AND URBAN DEVELOPMENT SUGGESTED FOR MOLDOVA

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## ABSTRACT

In recent history Moldova was a Soviet Republic, but gained independence in 1990 with the demise of the Soviet Union. Thus, the young republic inherited a road net work and its management by Soviet ways of thinking. There have been several internationally funded projects in recent years to encourage transportation and the economy of the road sector. Modern bridge and pavement management systems are naturally an efficient tool in this effort as is asset management. Within the framework of the Design and Implementation of Road Maintenance Reform, a couple of reports were prepared by a consultancy team on Asset Valuation and Pavement Management Systems. In the present paper some of the findings leading to a Moldovan Asset Valuation method as well as Pavement Management Systems are presented. An important factor for success is a wholeheartedly participation of the people to use the systems. The team focused on informing about possible methods for an evaluation and then collaborated upon a suitable method for the country. After going through the various methods for depreciation and new evaluation, a method was chosen were the asset for a given road was a function of a survey, mostly relying on the structural value. Class limits were selected after a previously made evaluation and practical aspects. Hence, the value of an object is based on the degree of degradation between new and the salvage value. The salvage value is depending on the road type. Road types in higher road categories with bound layers have a lower salvage value in relative terms; as the earth preparation works in relation to the cost of the pavement is lower.

# 1 INTRODUCTION

Moldova, a relatively young nation located in Eastern Europe bordering Ukraine and Romania, has a population of approximately 3.5 million and a size of 33 846 $km^2$. The climate is affected by the proximity to the Black Sea but the country lacks a coast line by itself. To the North there are some hills reaching an altitude of 400 m; the highest peak is 430 m only. However, this area is to be regarded as a different climate zone from the Black Sea Area.

In recent history Moldova was a Soviet Republic, but gained independence in 1990 with the demise of the Soviet Union. Thus, the young republic inherited a road net work and its management by Soviet ways of thinking. Since gaining independence and up to recently, only minuscule funding has been assigned for road maintenance.

During the last decade there has been little or no development on the procedures of maintenance management in Moldova. Data have been collected but have not been used for any particular purpose except to show the continued deterioration of the road network. The focus has been on emergency repairs only, as a consequence of the puny funding.

Efforts have been made by several development banks to introduce modern pavement and asset management principles to Moldova. In this context Pavement Management Systems (PMS) and Asset Valuation (AV) are discussed. By technology transfer and by discussions with road authority personnel a working concept was developed during 2010-11 with particular emphasis on Moldovan concerns. These are presented in the following text.

# 2 ROAD NETWORK IN MOLDOVA

The Moldavian State Road Administration (SRA) is responsible for management of about 9300* km Road Network. This responsibility includes planning for road infrastructure development through investments and, maintenance /rehabilitation of the existing road network.

SRA has faced significant lack of funds for road maintenance and rehabilitation for more than a decade. Consequently, the Road Network has been deteriorating fast and the vehicle operating costs have been increasing considerably.

Figure 1, shows the amount of road expenditures between 2006 and 2010 corresponding to about 0.24% of the total Gross Domestic Product (GDP) in 2006. Even if this amount was more than doubled in the following years it was still too scarce for anything other than emergency repairs. Some improvement was initiated of about 220 km of roads though. In spite of a budget 30% drop in 2009 SRA managed to undertake all emergency works and rehabilitate additional 64 km of the road network in that year. The decrease in 2009 may be a consequence of the global economic crisis and recession. SRA’s budget in 2010 however has almost doubled again as compared to 2008. The total road expenditure was about 1% of the GDP or about 1.2 billion Lei, also seen in Figure 1. According to SRA’s estimates, the ratio between road expenditures and GDP from 2010 and onwards (at least 3 years) will be somewhere between: 1% to 2%. This rate (1-2%) is generally considered to be a sufficient budget allocation for an acceptable level of road maintenance and minor rehabilitations of a road network in reasonable condition. The current road network condition in Moldova is far from reasonable though with only 2500 km of roads having an IRI less than 10 m/km. In other words there is a significant backlog in Moldova which calls for immediate and appropriate road maintenance and an increase in capital budget for at least six years ahead.

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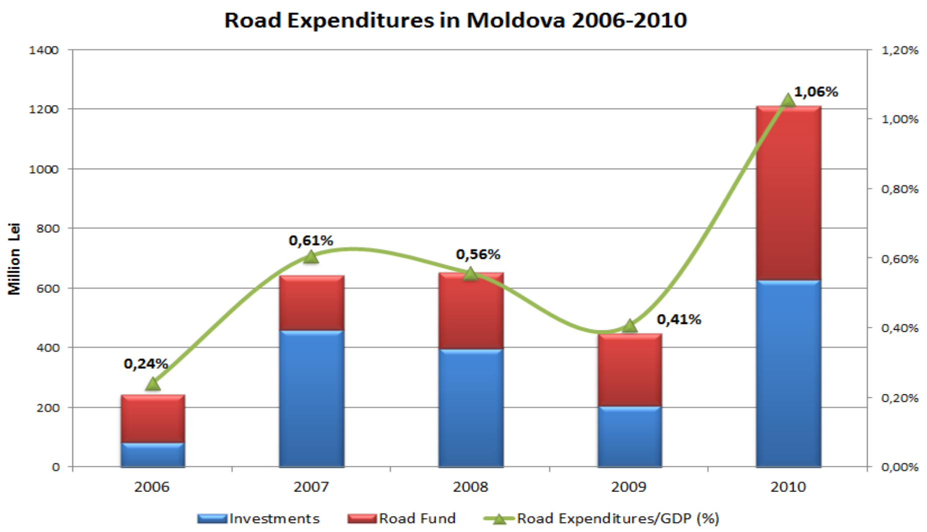


Figure 1. Road expenditures in Moldova, 2006-2010

# 3 CONCEPT FOR MODERN MAINTENANCE PLANNING AND MANAGEMENT

As indicated above, the reason for the current condition of the Moldavian road network is explained by long lasting insufficient funding for maintenance and improvement. Experiences have shown however that successful road management needs not only sufficient funding but also skilled management organization, clear processes, and access to effective tools and technique.

Moreover, modern road authorities today are recognised by their ability for planning and prioritizing road works of in order to get the best value of road expenditures, both in short- and long term. In other words, road management organization has to be modernized in order to include not only engineering issues but also allowing considerations of country wide cohesive development through wisely procedures for planning.

The concept discussed and introduced in Moldova takes its starting point in the interaction between four different driving forces namely:

(a) Road Users;
(b) Current Transport Policy;
(c) Economy; and
(d) Engineering.

It is anticipated that the this interaction will form the basis for modern maintenance planning where engineering solutions meet the transportation needs with consideration to the transport policy pursued. SRA has expressed its interest for this concept but there is no organization in place for practicing it as yet.

It is neither feasible nor desired to explain details of the all components of this concept in this article. However, one of the important components in this concept is use of modern tools and techniques for maintenance planning. These are briefly discussed in the following sections.

## 3.1 Pavement Management in Moldova

Similar to many other countries, Moldova has developed its own concept for Pavement Management System using commercial software. Since the beginning of 2000, Moldova has tried to introduce HDM 4 as a modern tool for pavement management, albeit with limited success.

In general, the most common reason for implementation failure of HDM 4 is a lack of understanding the purpose of the different analysis modules in the system. These require not only engineering judgement, but also proficiency in transport economy and data management. Staffs involved in the implementation process are often engineers with good knowledge on preparing technical matters. However, they tend to disregard transport economy as the basis for the prioritization of available resources. The latter is the one significant value added to the engineering plan and is one of the advantages of using HDM. Hence, successful implementation of HDM 4 is highly depending on transport economy and information technology and not only on the engineering matters.

Table 1, shows the initial activities proposed and partly executed for implementation of HDM 4 in Moldova

Table 1, initial activities for implementation of HDM

| Activity | Knowledge transfer | Hands on training | Comments |
|---|---|---|---|
| Data analysis | x | x | Working with available data |
| Writing script for data processing/analysis | x | x | For preparation of database, compatible with HDM |
| Structuring available data, preparing data for HDM 4 database | x | x | |
| Assigning maintenance standards | x | x | Through workshops. Needs knowledge on engineering and cost of different set of road works |
| Assigning maintenance strategies | x | x | Through workshops. Needs knowledge on engineering, available maintenance techniques and road deteriorating |
| Modern Maintenance planning and Management | x | | Combining engineering principles with transport economy and transport policy. |
| Management Function and HDM-4 | x | - | Lectures and workshops |
| Technical analysis tools within HDM4 | x | | Lectures and workshops |
| Road Engineering | x | - | Road Deterioration concept and models in HDM-4 |
| Road Works Classification in HDM-4 | x | - | |
| HDM-4, Economic Indicators and principles for economical evaluations | x | - | Needs multidisciplinary competences |
| Case study: Program analysis. | x | x | |

As can be seen in the Table the workshops played an important part in the implementation in Moldova. First, HDM-4 as an efficient tool for maintenance management was presented and its capability for different planning purposes was discussed in workshops at three occasions. Then, the program analysis tool in HDM-4 was described in theory and contextualized through modelling and evaluating 897 km of national roads in the country. For this example, several maintenance strategies for different roads in different traffic classes were discussed. A final strategy was chosen and agreed upon with the SRA staff. Cost estimates for different types of roadwork were compiled by Moldovan road experts. The condition of roads for the case study was visualized by using the available data in the program MapInfo. The changes in road network condition as well as timing of road work activities for each road section were also visualized using MapInfo.

As indicated above, only readily available data were used for the purpose of initial implementation of the HDM in Moldova. Experiences have shown that this will encourage the organization to continue the collection of data and highlights the importance of setting up proper strategy for the data collection. The purpose of this strategy is mainly to reduce the cost and time for data collection by focusing on knowing the characteristic of different set of data needed for different type of analysis. One does not necessarily have to collect all types of data as some of the parameters show a strong correlation with one another.

One of the most important tasks within this project was to undertake a study regarding asset valuation in Moldova. The following section describes the method used for this purpose.

# 4 ASSET VALUATION

## 4.1 Selecting a Method

The original task for the Moldovan Road Administration was to provide a simplified method. The key issue was to use existing data. Such data were available for pavement management purposes. There are inherent functions for user costs in the pavement management software that are suitable for determining the asset value in relation to the components new value. It is recommended to use these functions initially, that can be derived with the software HDM-4 version 2. Alternatively, the spreadsheet program RONET can be used with functions compatible with the aforementioned software.

For the annual changes of the asset value, there are several factors to consider. The yearly depreciation and work actions mitigating or improving the value. If new construction is excluded, any work action can raise the value and/or affect the depreciation rate. Typically, maintenance actions affect the deterioration rate only and therefore only affect the asset value over time. Actions increasing bearing capacity do affect the asset value directly as well and could appropriately be regarded as an investment. Further, a discussion is carried out on what to include in the road assets. Culverts that do not classify as bridges belong to the road asset. Other items include guard rails, traffic signs and markers, traffic lights, street lights, et cetera. For the simple method it would be difficult to include these as they are not included in the proposed PMS. However, their value could be appraised based on their new value minus depreciation also.

## 4.2 What is the value of the assets?

The important key issue is to make the assets comparable from a year-to-year basis. The value is either the as-built value, adjusted for inflation, or an imaginary rebuilt value, i.e. the present cost for constructing the road network. From either method depreciation is calculated as the network is not new. Each year actions or work will change the depreciation rate. Some work like rehabilitation can also increase the asset value, but in such cases the improved bearing capacity and or the larger traffic area should raise the asset value.

## 4.3 Establishing a baseline and target value

The initial valuation requires some ingenious thinking as a road network is something that has evolved over many years. The “as new” value can be estimated if the actual costs can be derived. In Moldova there are records left from the Soviet Union era when the roads were constructed. However, that was under a different currency system, and it may be difficult to appraise the true initial value. Then, one could estimate the construction costs for new roads corresponding to the actual size of the current road network as a comparison. If no or little data are available for such construction one can look at statistical data for nearby and similar regions.

Most roads have a salvage value, which is commonly regarded to be about 20% of the new value. Thus, no asset valuation estimate should be less than 20% of the estimated new value.

There are nevertheless reasons to consider that the salvage value in many cases is higher than 20%. One plausible assessment would be the rehabilitation costs for some recent project compared to new construction. The difference would be near that of the salvage value.

When the new value and the salvage value are established one could assess the annual depreciation of a road over its technical length of life. This is usually 20 years for flexible and 30 or 40 years for rigid pavements. In a perpetual state the median status of a road would be its half-life, i.e. ten years for the flexible pavements. So a simple target value for asset management would be the ten year depreciated value, when a flat rate depreciation model is being used. In reality roads do not deteriorate linearly. The structural degradation as well as user serviceability degradation does not occur in a linear fashion. The choice of the depreciation model could affect both the value itself and the pavement management strategies as well. The differences are discussed below, but for the simple model the median life is a sufficiently reasonable target value.

Note also that when the road network is growing, either in size (new roads) or bearing capacity, the median is shifted towards a higher asset value.

## 4.4 Deterioration rates

The deterioration rate is the amount of depreciation of the value usually on an annual basis. In this context, there is a “new” value, corresponding to the actual construction costs. At the other end of the road life there is a salvage value, i.e. the value of road which is deteriorated to the state of not travelable, but still physically being in place. Usually, this value is taken to be about 20% of the construction cost. It stems from considering a proportion of costs for preparing the subgrade. It is to be noted that this value in fact can be much higher, especially if land use costs are to be included. In each and every case a bearing capacity test appraises a value; leading to an appropriate overlay design, with a known cost, which in turn could be related to new cost.

Assuming a salvage value of 20% and a technical design life of 20 years and no major overlay nor rehabilitation the annual flat depreciation is:

$0.8 * 1/20 = .04$ (I.e. 4 percent)

PCC pavements have a 30 or 40 year design life so depreciation is thus 2.67 and 2 percent respectively. With this method a “half-life” value cold serve as a target, meaning that the asset value should be 60% of the new value for any pavement technical life. Consequently, with a salvage value of say 40%, the median value is 70%.

In reality though, the depreciation rate is not constant over time. First there are maintenance actions that alter the rate, and there are overlay actions that extends the life and thus affect the future valuation.

Most pavement management systems including HDM-4 adopt a user cost driven approach. Thus, a new road with an initial IRI of 1.0 mm/m will last a few years before the roughness has reached a level that affects the user costs more than marginally. After reaching this level the effect on user costs is a square function of its value. Thus, there is little depreciation in the pavements’ early life and very much so in the later years. The PMS will tell you when and how to do the maintenance and repair. If one is able to follow the PMS recommendations, the asset value will be much higher than for the flat rate depreciation scheme.

A structural approach will produce yet another value. The initial rutting rate is somewhat higher due to compaction by traffic. It can be argued that this rutting is not an actual depreciation, but nevertheless it affects the time to the next overlay and thereby compromise the structural capital. Then, the structural degradation is rather linear in relation to traffic over the years, but by the end the pavements starts to crack and the degradation of deeper layers will accelerate as will the costs for repair.

At mid-life (10 years) the structural value is also higher than the flat rate, but it is much closer than the user cost model is. By two thirds into the life the asset value starts to decrease rapidly with both models in comparison with the flat rate model.

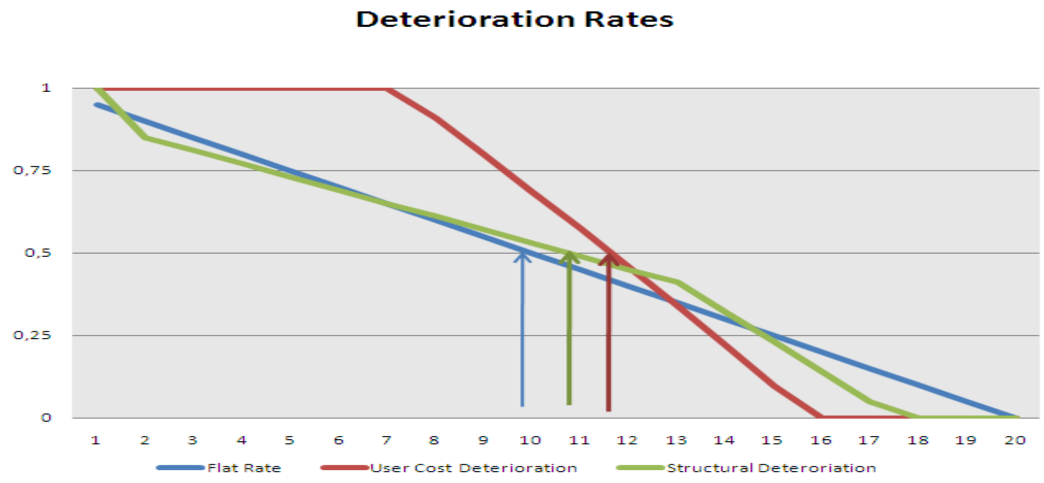


Figure 2. Different depreciation rates compared

As can be seen in the Figure 2 the time it takes for the assets to reach their half-life value is different depending on the model. The figure illustrates that if a user-driven pavement management system is adopted, then the target asset value could be higher than 50% of the as new value. (In the figure about 70%). Note also that the user costs are depending on such factors as speed limits, traffic flow, et cetera.

## 4.5 RONET model

In the initial suggestion RONET was included as a way to determine the road network valuation. In the Evaluation Report on the Pavement Management Systems RONET is not recommended for program or project levels, but is considered sufficient for the strategic network evaluation. It uses the same type of data as for the HDM-4 model, but it does not process the data further as is needed for predictions. Thus, the RONET spreadsheet can be used initially, but one has to bear in mind that the deterioration models will change as feedback from previous years will adjust them.

## 4.6 HDM-4 model

The Pavement Maintenance System is recommending HDM-4 version 2 as the primary source as a modelling tool for assessing user cost and making predictions about future deterioration and as a decision tool for actions on maintenance and rehabilitation. There is no actual need to use a different scheme for the asset valuation and thus the Asset Management System (AMS) and PMS would be fully compatible. There will be little or no extra costs associated with the AMS calculations either, so the future asset valuations can utilize the PMS data.

## 4.7 Validation model

As was previously discussed the User Coast Depreciation model may underestimate the actual value on very rough roads, where the roughness stems from surface deficiencies. As rehabilitation projects go underway they are likely to be subjected to bearing capacity measurements before the overlay design is determined. Follow-up studies of the bearing capacity work are strongly recommended as to validate the increased bearing capacity. This will also serve as a validation tool for the equations used by the HDM-4 software.

## 4.8 Alternative model with Artificial Intelligence

In recent years Neural Networks (NN) has been suggested as a tool to aid for asset evaluation. This method is suitable for handling incomplete and noisy data. As available data are scarce and recalculated from old equipment the usefulness of a neural network seem to be most appropriate.

A neural network is simulating and creating an expert system by training samples. It has been suggested for pavement management systems due to the capabilities to refine and identify the best option in a complex decision making process. As an alternative to the RONET valuation the NN method can be a most viable alternative.

## 4.9 Previous measurements compared to the desired present asset value.

A visual survey of the Moldovan road network was carried out by a consulting firm, (World Bank 2006). This study rated the roads mainly in a structural fashion. For the national roads the bad and very bad categories comprised about 2/3 of the national road network. From a management standpoint one would have about 5 % of the roads in the very bad category. This corresponds to the design life of 20 years and sections due up for rehabilitation. Looking at the mean and standard deviation of the data, it seemed that there was a shift of almost one standard deviation towards a more deteriorated state for the national roads in Moldova. This corresponds to an asset value of only 40% of new as compared to the target value of 60 % for asphalt roads with a salvage value of 20%. To get to this point about ten years of neglecting sections due up for rehabilitation was estimated. To derive these figures the class limits for the categories very poor, poor, acceptable, good and very good was assumed to be represented by a normal distribution. This does not mean that the distribution of deficiencies is normally distributed. In fact most deficiency parameters are skewed by values, e.g. rutting. It is just a way of finding of what to expect in rating categories for the various parameters; and it was helpful for presenting scenarios. Local road categories in the 2006 study followed these class limits also, but with an even greater shift from the desired state, see Table 2.

Table 2. Comparison of distributions of actual rating 2006 and shifted class limits.

| | Bad (and very bad) conditions | Fair conditions | Good conditions | Very good conditions |
|---|---|---|---|---|
| National Roads rated | 67.6 % | 23.1% | 5.3% | 2.0% |
| National Roads 0.95Std Dev shift | 67.4% | 25.3% | 6.6% | 0.7% |
| Local Roads rated | 81.4% | 13.8% | 4.7% | 0.1% |
| Local Roads 1.4Std Dev shift | 81.6% | 15.5% | 2.7% | 0.2% |

# 5 OBSERVATIONS AND RECOMMENDATIONS

The user-oriented IRI is an excellent input parameter in the PMS and as such very suitable for road network evaluation, and hence for AM purposes as well. However, in Moldova the IRI is converted from a bump integrator collection of data. The bump integrator suffers from many drawbacks.

- It moves rather slowly in traffic;
- Recoding sessions are limited, meaning frequent stops;
- The transfer function to IRI has limits, thus quality is deteriorated;
- Yearly calibrations are needed and there is a possible shift in data as parts wear out.

Today, most road agencies will collect IRI-data with a contact-less system that does not wear out. In addition, variants of the General Motors profiler allow for collecting the entire longitudinal profile. With modern on-board computers the data can be stored, so that not only the IRI can be calculated, but also other measures like any car or truck behaviour. The test vehicles operate at normal traffic speeds 8-100 km/h, so the data losses are minimal. The simplest systems carry a unit that can be attached to any platform (vehicle), but there are other systems that carry many sensors as to form a transversal profile as well, that also reports rutting.

The national roads in Moldova comprise 3677 km and since the capacity is 800 km a day, it will take only a week to cover the entire network for such a vehicle. (Add a few days for rain as the surface has to dry during testing). If such a system is used the asset value could easily be compared from a year to year basis. In addition the deterioration functions used in the HDM-4 model could be validated and adjusted accordingly. After, say a five-year period the need to measure every year could be decreased, and other public roads could also be included in the measuring program. (About 26% coverage is needed to accurately describe the road network condition). Note also that since the roads in Moldova is rather rough, the IRI average over many sensors is better than using the wheel path sensors only.

For structural evaluation the Falling Weight Deflectometer is recommended. At least for the project level of Pavement Management it is necessary. As those data are spatially too limited for Asset Management purposes it cannot be used directly. However, it will serve as a validation tool for the increase in bearing capacity which is an important factor for the asset valuation. One must keep in mind to do a follow-up second measurement after the rehabilitation work is completed. This will provide valuable information for the PMS and AMS as well as there is a direct relationship of the change of asset value.

Regarding the size of the Moldovan National road network, one could consider a FWD network level structural investigation as well. With a 500 meter spacing the capacity is about 100 km per day. Thus, such a study will take less than eight weeks to complete.

FWD today is often done simultaneously with a Ground Penetrating Radar (GPR) Unit, from which the asphalt layer thickness can be determined.

# 6 CONCLUSIONS

There are many items that could be included in asset management systems. In this context, roads, bridges and culverts are to be included in the valuation.

In order to compare annual changes, a base line and target value should be decided by definition. The important aspect is to get a comparable value rather than an exact sum. The as-new value can be estimated by historic data. These data have to be adjusted to a virtual new value, based on production prices in similar areas. In addition, recent rehabilitation work costs are compared to the new production costs. Hence, a good idea about the salvage value of the road is assessed.

The annual value is depreciated by a linear model between the new value and the salvage value. The median of values (Half-life) defines a target value.

The deterioration rates for various road types can be found by using RONET and HDM-4 models.

As an alternative a neural network simulation process is tried to see if it complies with the RONET models. A relation could also be established based on some input parameters, like location, traffic, age, type, *et cetera* with the actual costs of recent rehabilitation work. These are then extrapolated to the entire network.

Actions that increase the road asset value should be defined. (Rehabilitation and possibly some thin overlays).

Actions that affect the road deterioration rate should also be defined.

As data are available, the effects of increasing structural capacity could serve as a validation of the models.

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