SUSTAINABLE MAINTENANCE IN ROAD ADMINISTRATION BASED ON ASSET MANAGEMENT

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ABSTRACT

Asset management is an issue which is implicated in several sectors of a national economy in Slovakia. Competition, regulations and new conditions on the open European market require from the road agencies to solve the issues connected with the effectiveness of the rejuvenation and management at a high rate obtained assets.

The regional road administrators struggle with the volume of roads in their sphere of authority and limited budget to secure a functioning rural road network. Without an asset management system a lots of funds flow in wrong assets while on the other side lots of socio-economic benefits are lost due to poor condition of other assets. That combined with the request that their maintenance plans have to meet the requirements of sustainability principles led to a design of a working improvised asset management system to fulfil the role of a proper asset management system.

1 ROAD ASSET MANAGEMENT IN SLOVAK REPUBLIC

The road infrastructure of Slovak republic is the nation's main asset with vital on economical, political, administrative, cultural and social significance. As such a system of asset management is being prepared for an effective administration of road network of Slovak republic.

Asset management, broadly defined, refers to any system whereby things that are of value to an entity or group are monitored and maintained. It may apply to both tangible assets and to intangible concepts such as intellectual property and goodwill. Asset management is a systematic process of operating, maintaining, and upgrading assets cost-effectively.

Asset Management as applied to the roads sector represents a systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organized and flexible approach to making the decisions necessary to achieve the public's expectations.

1.1 Road Network of Slovak Republic

The road network of Slovakia consists of 391 km of limited access roads (motorways and express roads) and 174 367 km of 1st, 2nd and 3rd class roads. The main objective of motorway network is to provide transit according to Pan-European transport corridors, namely the IV., V. and VI. corridor. The purpose of express road network is to collect and transfer the transport generated by Slovak republic's regions and contra wise to distribute transport from foreign countries from motorways to the body of Slovak Republic. The 1st, 2nd and 3rd class roads fulfill the service task of transportation between and within regions of Slovak republic. On top of this network a network of urban communications and minor purpose communication is connected.

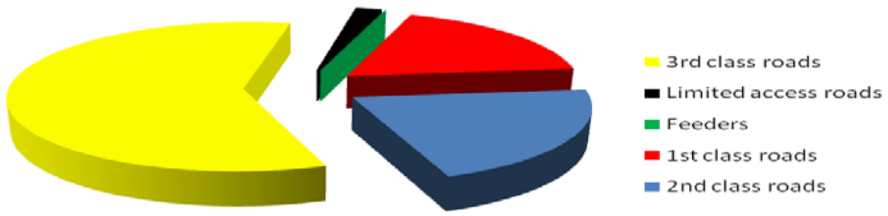


Figure1: Composition of road network of Slovak republic.

1.2 Road Administrators and Asset Management System of SR

Different types of roads have different owners and administrators with their executive offices.

Table1: Road network administrators of Slovak republic

Type of communication	Owner	Administration and maintenance	Executive administration office
Motorways	State	National Highway Agency	Minister of Transport, Construction and Regional Development
Expressways	State	National Highway Agency	Minister of Transport, Construction and Regional Development
1st class roads	State	Slovak Road Administration-Bratislava	Regional transportation offices
2nd class roads	Regional administrations	Slovak Road Administration	District transportation offices
3rd class roads	Regional administrations	Slovak Road Administration	District transportation offices
Urban roads	Municipal authorities	Municipal authorities	Municipal offices
Minor purpose communications	Municipal authorities	Municipal authorities	Municipal offices

This paper is aimed on the topic of asset management; therefore the viewpoint of administrators of road network will be crucial. Their task is to develop and maintain a safe,

eco-friendly and efficient transport system. This may be seen as securing a fluent and safe transport on them entrusted roads by providing maintenance, winter service, repair, reconstructions and acquisition of new assets according to concept of development of road network of Slovakia.
For securing a complex asset management system a decision was made to implement an asset management system for every administrator and try to make them cooperate. Of course since these administrators have separated budgets the cooperation we speak of consists mostly of data sharing. The analysis process and decision making process thus have to be individual for each and every administrator.

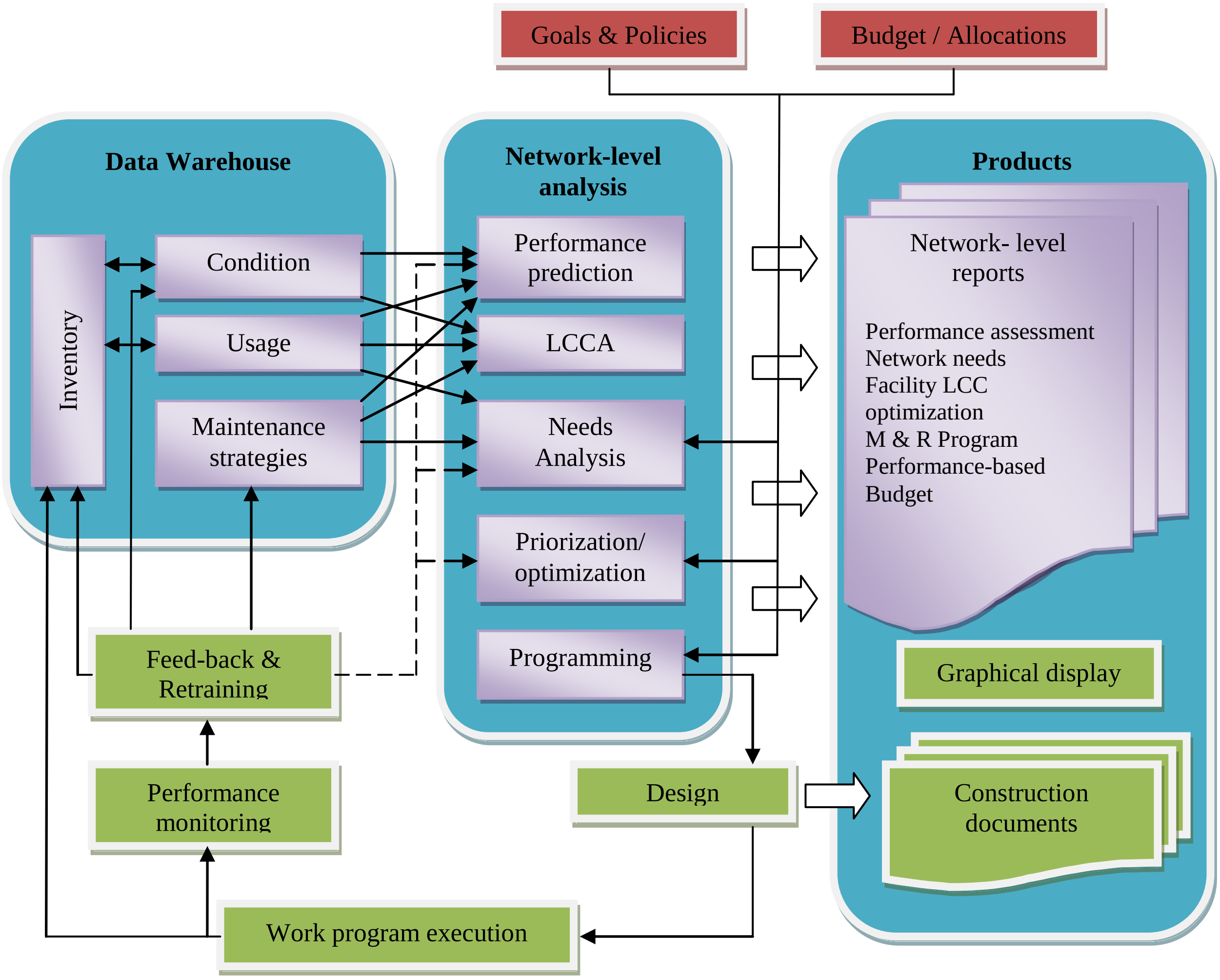


Figure2: Asset management system model in use

A data warehouse stores the main input data and should be separated for every administrator, these data are then used in network-level analysis. The network level analysis will use the same mechanic for every administrator with different inputs from data warehouse (internal inputs) and data regarding goals policies and budget (external inputs).
The practical implementation of this system is sadly lacking. For once, the data warehouse is incomplete. It lacks the 2nd and 3rd class roads data. Secondly, transparent and effective software capable of life cycle analysis of new constructions is not available. The first issue is surprisingly a bigger concern than the lack of analytic software which can be partially substituted by foreign software (like HDM-4). It points out the undervaluation of 2nd and 3rd class roads we're witnessing. The maintenance of rural roads has been a relatively lower priority in funding in last two decades, despite the rural road network comprising a large

proportion of the overall road network in Slovakia. This has resulted in significant deterioration in the technical condition of the rural road network. Unexpected and sudden increase of traffic volume on the roads, caused by general expansion of capital construction and development projects in recent years, incurred that road structures, not designed for such traffic load intensity deteriorate much faster than planned.

2 MAINTENANCE STANDARD FOR 2ND AND 3RD CLASS ROADS WITH REGARDS TO SUSTAINIBILITY AND LIMITED ADMINISTRATOR BUDGET

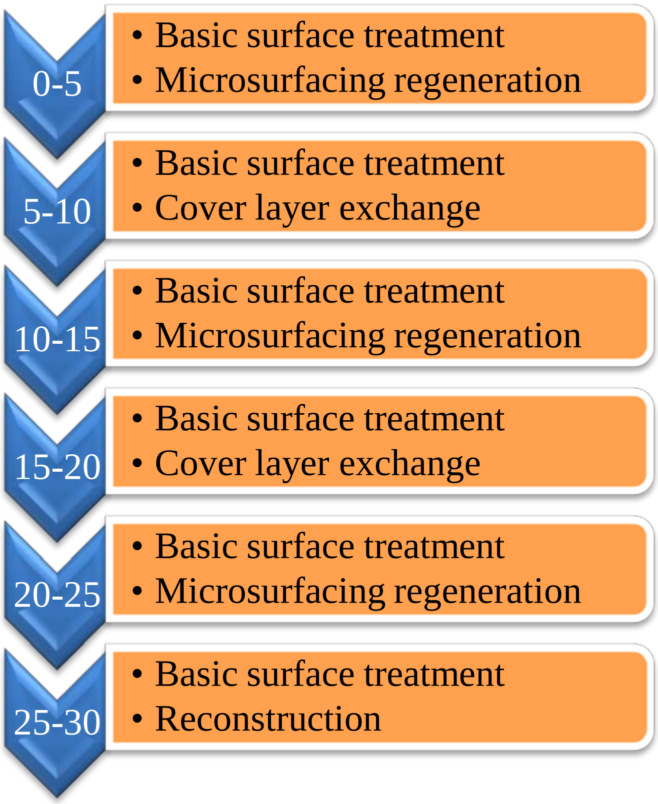
The purpose of maintenance and repairs of asphalt pavements is to extend the useful life of the pavement, maintain a smooth riding surface, and prevent water from entering the underlying soil. Limited manpower and resources have increased the importance of M&R to the life of a pavement. To keep a pavement in the best possible condition, it is important to use an effective pavement management system (PMS). Since the 2nd and 3rd class roads aren't systematically surveyed and their state isn't stored and used as an input for PMS, the municipal administrators of these roads rely on fixed maintenance standard.

2.1 Fixed Maintenance Standard

A maintenance standard is a schedule of repair and maintenance works which also represents the allowable limit for road deterioration. A standard is based on road class, characteristics of traffic and general operational practice. Generally, when roughness reaches close to the standard (fixed International Roughness Index, IRI), any treatment is required to restrain road roughness to go beyond the standard. Standards have to optimum considering cost and road condition, and should be set at network level. The fixed maintenance standard prescribes the maintenance and repair procedures to certain years.

Table2: Common pavement repair technologies

Technology	Period	Description	Effect
Basic surface treatment	1 year	Pothole patching and Crack sealing according to administrators available technologies.	A local defective part of pavement is treated for re-acquiring of lost geometry and structural properties.
Microsurfacing regeneration	5 year	Microsurfacing is a cold mixed polymer modified thin asphalt layer lied with traveling paving truck.	Microsurfacing restores lost surface properties and protects and preserves, extending pavement life.
Cover layer exchange	10 year	Upper part of the road is milled off and replaced with a new bituminous layer. The thickness may vary.	Continuous regaining of geometric, structural and surface properties.



The maintenance and repair procedures prescribed by fixed maintenance standard don't always correspond with the actual needs of the road conditions nor do they take into account the budget possibilities of the road administrator. Nevertheless it's an empirically based schedule of pavement treatment works which guarantees a good condition of the road throughout its whole life cycle. The downsides are obvious; the overall idea doesn't correspond with the procedures described in asset management theory with all the impacts that fact has on effective road administration.

Figure3: Current Fixed maintenance standard for 2^{nd} and 3^{rd} class roads in SR.

2.2 Lower Cost Standards Assessment for Sustainable Maintenance

At this time the ratio of pavement conditions on 2^{nd} and 3^{rd} class roads and the amount of accessible resources of road administrators of these networks begin to reach critical levels. While a complete effective road asset management even of motorways and 1^{st} class roads is still far from completion a substitution solution have to be made to help road administrators of lower class roads.

Therefore a search for lower-cost maintenance standards and the process of assigning them to individual roads started as a part of research on University of Žilina. The aim is to assess the possibilities of cheaper maintenance while still providing a fair pavement quality to the society. This also means that instead of having part of road network maintained in sub-optimal and part in over-optimal condition, more homogenous ride quality on whole network will be achieved.

The calculation was made in PROGRAM mode of the HDM-4 workspace with the use of calibration data provided by the Slovak Road Administration.

We defined a 10 km long fairly straight and level 3^{rd} road class S 7.5/80 road category section. We've chosen low traffic load on this section (only 1000 AADT) in perfect condition similar to condition right after construction.

For the analysis we used a HDM-4 deterioration model. Five alternative programs each with five different maintenance standard were chosen:

- basic variant;
- microsurfacing based variant;
- one major cover layer exchange based variant;
- one microsurface based variant;
- balanced cover layer exchange based variant.

The average IRI graph represents the main surface attribute change throughout the lifecycle of the road section of all three programs.

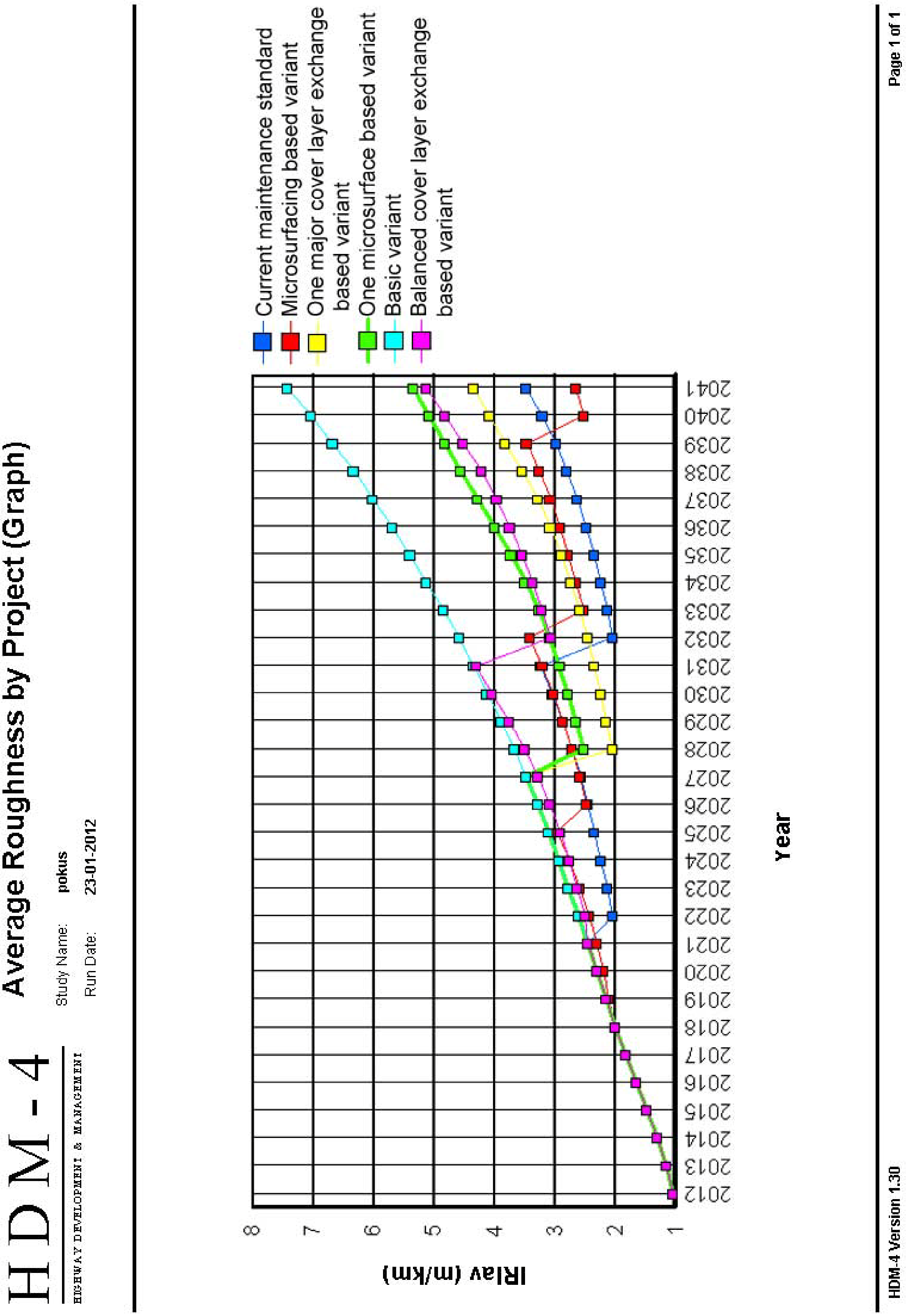


Figure4: Calculation results- Average roughness by project graph

2.3 Technical Point of View

From the legislative viewpoint the TP 04/2000 of Slovak Road Administration prescribes classification index for different road classes according to IRI on that road section.

Table3: Classification index according to IRI

Classification index	Limited access roads	1st and 2nd class roads	3rd class and urban roads
1	<1.9	<1.9	<3.30
2	1.9-3.30	1.9-3.31	3.31-5.00
3	3.31-5.00	3.31-5.00	5.01-8.00
4	5.01-8.00	5.01-10.00	8.01-14.00
5	>8.00	>10.00	>14.00

The limit for acceptance is the 3rd classification index which is characterized as "satisfactory index". Beyond that point the pavement doesn't meet the criteria for adequate operational service. As we can see from fig.4, some of the programs at the end of the road section life exceed the boundary of 5.00 IRI for 2nd class roads and 8.00 IRI for the 3rd class. From this view points:

- **basic variant-** is appropriate only for 3rd class roads which doesn't exceed the 1000 AADT limit and/or aren't suffering excessive high load vehicles encumbrance.
- **microsurfacing based variant-** safe to use on all 2nd and 3rd road class roads.
- **one major cover layer exchange based variant-** fairly safe to use on all 2nd and 3rd road class roads.
- **one microsurface based variant-** may be appropriate even for 2nd class roads with traffic load under 1000 AADT especially if they aren't suffering excessive high load vehicles encumbrance.
- **balanced cover layer exchange based variant-** may be appropriate even for 2nd class roads with traffic load under 1000 AADT especially if they aren't suffering excessive high load vehicles encumbrance.

2.4 Financial and Economical Point of View

In accordance with the aim of the research the task was to find cheaper solutions for the maintenance process. Therefore all the proposed programs are significantly cheaper than the current maintenance standard.

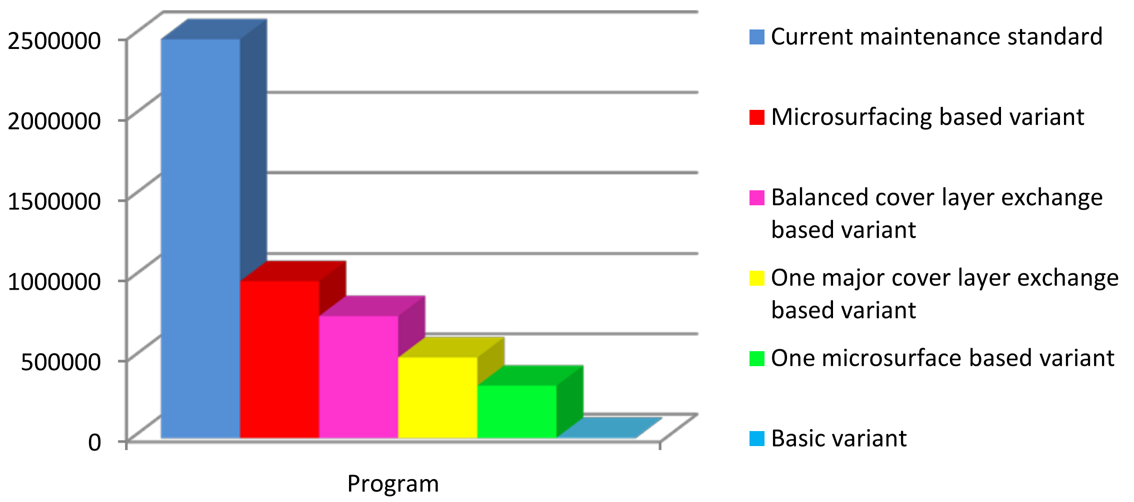


Figure5: Program cost comparing

The financial cost isn't the only variable we have to take into account while assessing the suitability of these programs. The HDM-4 program offers an economic analysis of defined variants which compares the socio-economical benefits of studied programs with the base alternative. Two economical analyses were made each with different base alternative.
Study 1 had the Basic variant (only basic surface treatment) set as its base alternative, the program took the costs of the variants, monetized socio-economic benefits of a variant as a difference between the base alternative and studied alternative and calculated the main economical effectives indicators namely NPV and IRI.

Table4: Study 1. Program "Basic variant" as base alternative

	Name	Description	Costs	NPV	IRR
1	Current maintenance standard	see fig. 3.	2 480 085	1 691 695	13.9
2	Basic variant	Whole lifetime of only basic surface treatment.	2 643	0	0
3	Microsurfacing based variant	Basic surface treatment with 25mm microsurfacing in 7th 16th and 25th year.	977 588	1 723 229	12.1
4	One major cover layer exchange based variant	Basic surface treatment with 40mm cover layer exchange in 14th year	502 654	2 045 110	30.9
5	One microsurface based variant	Basic surface treatment with 25mm microsurfacing in 14th year.	327 279	1 588 528	37.9
6	Balanced cover layer exchange based variant	Basic surface treatment with 20mm cover layer exchange and 25mm microsurfacing in 8th 18th and 28th year.	760 652	1 236 838	15.6

Table5: Study 2. Program "Current maintenance standard" as base alternative

Nr.	Name	Description	Costs	NPV	IRR
1	Current maintenance standard	see fig	2 480 085	0	0
2	Basic variant	Whole lifetime of only basic surface treatment.	2 643	-25 017 659	neg
3	Microsurfacing based variant	Basic surface treatment with 25mm microsurfacing in 7th 16th and 25th year.	977 588	31 534	3.5
4	One major cover layer exchange based variant	Basic surface treatment with 40mm cover layer exchange in 14th year	502 654	31 401	neg
5	One microsurface based variant	Basic surface treatment with 25mm microsurfacing in 14th year.	327 279	-103 166	neg
6	Balanced cover layer exchange based variant	Basic surface treatment with 20mm cover layer exchange and 25mm microsurf. in 8th 18th and 28th year.	760 652	-454 856	neg

Study 2 followed the same procedure; the difference is that as the base alternative was set as the current maintenance standard.
As suspected in study 1 (Tab 4) we see that all programs attained high NPV and IRR. It's because the HDM-4 monetized socio-economical benefits from road user's costs between poor surface conditions of base variant and the much better conditions of studied variants fairly high. Therefore even the ultra-low cost of this base variant can't compete with other more balanced variants thus making it quite unsuitable.
Study 2 showed us that only the microsurfacing based variant and one major cover layer exchange based variant achieved a positive NPV from which only microsurfacing based variant achieved a positive IRR.

2.5 The Final Suitability of Maintenance Standards

Overall it's impossible to rank these alternatives as the road network is inhomogeneous and dynamic environment. The traffic load, condition of particular road section, volume of maintenance works in contrast to road administrator capabilities and others factors play a huge part for choosing the right maintenance standard

Table6: Maintenance standard ranking

Viewpoint	**Current maintenance standard**	**Microsurfacing based variant**	**Balanced cover layer exchange based variant**	**One major cover layer exchange based variant**	**One microsurface based variant**	**Basic varian**
Cost	6th	5th	4th	3rd	2nd	1st
Technical suitability	1st	2nd	5th	3rd	4th	6th
Economical efectvieness	4th	5th	3rd	2nd	1st	6th
Overall	3rd	4th	5th	1st	2nd	6th

We can rank these proposed maintenance standard from different viewpoints and try to rank their overall score as seen in this tab but for responsible assignment of an maintenance standard to an road section we still need a deeper system based on our results.

2.6 The Temporary Optimum Maintenance Standard Selection System

The asset management system we striving for should enable us to assess the whole road network and plan maintenance and acquisition of new assets for the whole network in a dynamic fashion.
Nevertheless an easy-to-use system for road administrators of low level roads is needed ASAP. Proposal of this system is schemed in fig 6 and we've call it Optimum Maintenance Standard Selection System. The first two stages of this system (Data gathering and Input) are static; the main stage "The process" is a cycle which takes the with traffic most encumbered road section from a road chart and then assigns a maintenance standard to it. Afterward the cycle is repeated with another road section in line. (Note that this scheme uses as a assessment tool the HDM-4 software, based on this part of research results from tab 6 could be used to substitute the HDM-4 calculation process with a simple human assessment procedure.)
The idea is that the lower on the AADT chart we go the more important the cost viewpoint will be at the price of economical effectiveness.

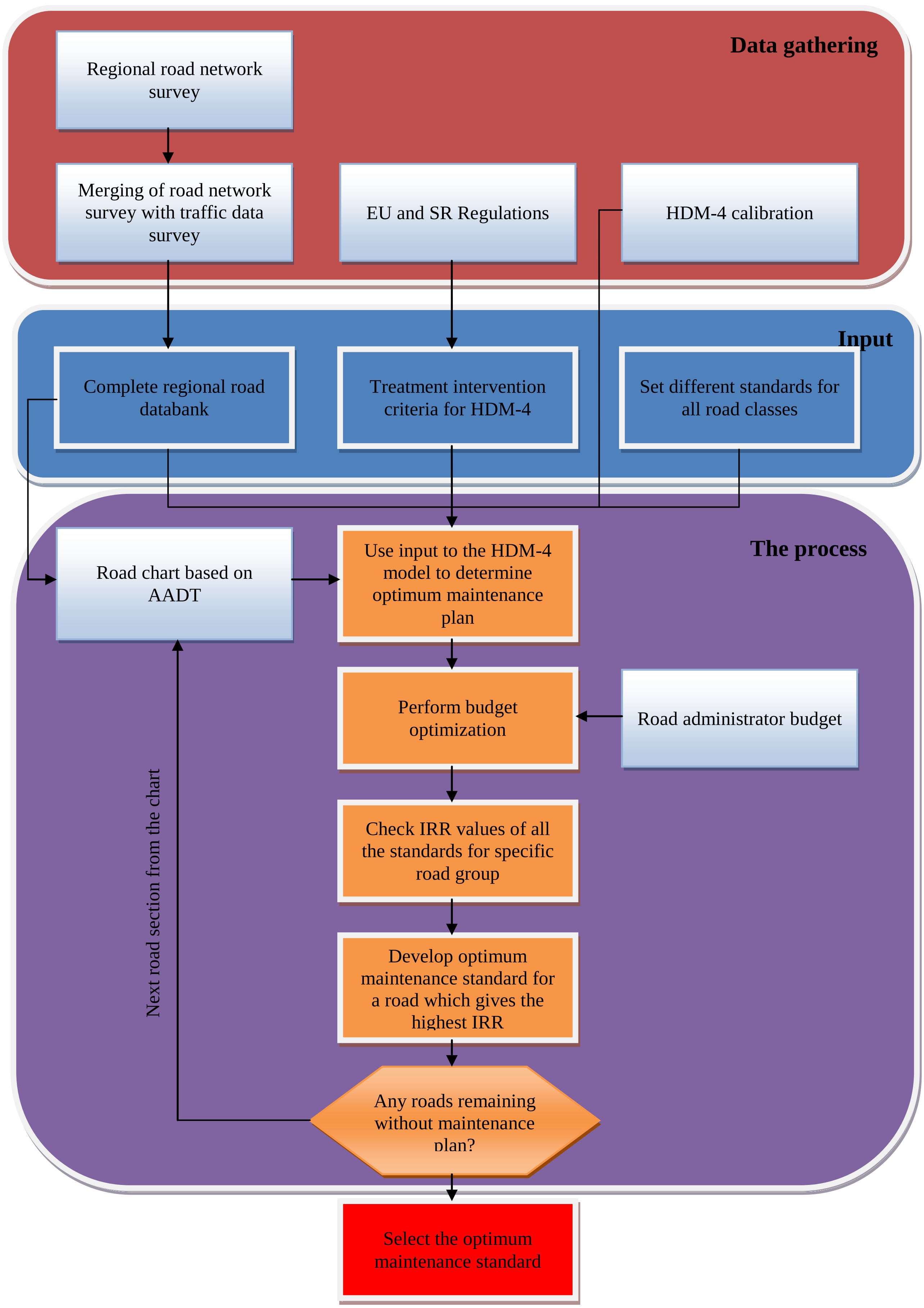


Figure6: Optimum Maintenance Standard Selection System

The result should be an improvised asset management system which will increase the overall effectiveness of road network while securing a sustainable maintenance of the road network.

3 CONCLUSION

Effective asset management from the view of road management means, that road agency is capable to face real costs for the construction of the assets, to make decision making process about repair, rejuvenation or reconstruction of the assets based on economical criteria.
While a working effective asset management is in design a quick solutions have to be found to ensure a sustainable maintenance system for the most encumbered road administrators namely the Regional administration responsible for management of the vast low class road network. This paper shown the process of assessing various maintenance strategies and described a scheme of using the result for a temporary asset management system this administrators could use.

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This contribution is the result of the project implementation: "Independent Research of Civil Engineering Construction for Increase in Construction Elements Effectiveness" (ITMS: 26220220112) supported by the Research & Development Operational Programme funded by the ERDF.

„This work was supported by the Slovak Research and Development Agency under the contract No. LPP-0402-09“.