EFFECTIVENESS OF NATIONAL ROADS MAINTENANCE MANAGEMENT IN POLAND

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BETTER GOVERNMENT
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Dear Readers,

Recently, public discussion on the road network development in Poland focused mainly on building new motorways and expressways. At the same time Polish public opinion is less interested in other aspects of road infrastructure. The present report, written by Joanna Archutowska and Jana Pieriegud under the frame of Ernst & Young Better Government Programme, is trying to reverse this trend by drawing attention to the comprehensive issue of the effectiveness in management of existing road infrastructure.

It is worth remembering that road maintenance is not only routine maintenance i.e. preservation and cleaning, but also its structural maintenance, i.e. repavement and other reconstructions works. These elements have a direct impact on comfort, safety and travel time which translates directly on the effectiveness of the whole economy.

Effective roads maintenance should take into account both technical and economic parameters and achieve the best possible results using limited resources. This task is difficult to achieve so it is worth to take a look at the international experience, choose the best practices and try to implement them into Polish road maintenance management model, as the authors of present report have done.

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Summary

Like all technical facilities, transport infrastructure requires maintenance and renewals so that it can serve its users properly. The technical condition of roads, as well as the users' comfort and travel time depend directly on the effectiveness of those works. Then again, good condition of roads indirectly affects mobility of the society, spatial coherence of the country and the development of the national economy.

In Poland the responsibility for maintenance of national roads rests with the state through the road authority, the General Director for National Roads and Motorways with the road administration acting on his behalf, which is the General Directorate for National Roads and Motorways (GDDKiA). An objective assessment of GDDKiA's activity in the field of infrastructure maintenance does not seem possible without a set of indicators measuring the effectiveness of road maintenance management.

The main objective of this research project was to systematise indicators measuring the effectiveness of road maintenance used in the international practice, to assess GDDKiA's maintenance management system and to indicate the best practices used by foreign national road authorities, which would contribute to increasing the effectiveness in management of national road maintenance in Poland. The effectiveness in national road management depends though on management efficiency of the road authority, as well as on the effectiveness of the entire system of financing and management of road investment and maintenance projects. Considerations on the roads administrative division, as well as the financial and budgetary principles are however beyond the objectives of this report.

The report consists of five major chapters. The first chapter presents the main premises for undertaking the research project as well as the objectives and stages of the analysis. The second chapter defines the effectiveness and various approaches to its assessment, specifies individual groups of indicators and sets out the methodology to analyse the effectiveness in road infrastructure management. The following chapter describes the national road network in Poland, the organisational structure of national road management and the existing system of road maintenance management, as well as presents an analysis of selected indicators measuring the management effectiveness of national road maintenance in Poland. Chapter four contains a comparative analysis of the management systems for national roads maintenance in selected European countries as well

as a list of best maintenance practices applied by the leading road authorities all over the world. They include, inter alia, life-cycle pavement costing, management of maintenance contracts, maintenance standards from the road users' perspective, and measures for reduction of traffic hindrances on roadwork sites.

The assessment of the national road maintenance management in Poland shows that over the recent three years GDDKiA achieved a considerable progress in establishing standards for routine maintenance, assessment of the road surface condition, data collection and storage, whereas in other areas such as, for instance, the system of reporting and management analytics, further improvements are necessary. Referring to the best international practices, recommendations are made in the last, fifth chapter of the research report as to short- and long- term actions, which could contribute to increasing the effectiveness of road administration in Poland and thus improving efficiency of the state. Some of the management tools serving the assessment of road maintenance management effectiveness presented in this report may be also useful for other road authorities in Poland.

In view of the specificity of the undertaken research topic, it was necessary to present basic terms used in road engineering and management in Poland and abroad, which are found in Appendices A and B at the end of the report. The remaining appendices include statistical and informational material collected while preparing the report.

1. Introduction

There are no effective or ineffective companies; there are just companies that are better or worse managed.

Peter Drucker

1.1. The Research Problem and Objectives

At the beginning of 2011 the total length of public roads in Poland was 406,100 km, out of which 18,600 km were national roads. The length of roads of the highest standard, that is motorways, was 857 km, expressways made up another 675 km. Over 1,400 km of public national roads had been under construction. At the present stage of the road network development in Poland the most attention is put to the value of investment outlays, effectiveness of using EU assistance funds and the quality of construction works on motorways and expressways. Moreover, the major problems of road engineering in Poland include a backlog of maintenance works on the existing national road network – both in the field of routine and structural maintenance. One must also bear in mind that as new road sections are constructed, the maintenance needs will rise in the years to come.

Research Problem

Road maintenance includes its current maintenance, defined in international literature as routine maintenance, as well as road repavement and reconstruction referred to as structural maintenance.

Road routine maintenance includes repairs and cleaning that prevent deterioration of the road surface, road elements, engineering structures, the right-of-way facilities, as well as activities to preserve aesthetic qualities of the road; actions connected with winter road maintenance (snow removal and anti-skid measures in winter); repair works to ensure traffic safety and comfort.

Road structural maintenance (repavement or more comprehensive renewals) has the objective of restoring (reinstating) the original condition of the road (also with the use of building materials different from the ones used in the original construction technology), whereas road upgrading or modernisation (also reinforcement) consists of works increasing the technical and operational parameters of the existing road without a need to change the right-of-way boundaries.

Over the recent years we could observe an improvement in the condition of national roads and the safety of road traffic

due to increased spending on road renewal and upgrading works. Nevertheless, at the end of 2010, 22% of roads were in an unsatisfactory condition and another 19% of roads were in a poor condition, which means that they required prompt repavement works.

The condition of roads and the riding comfort result from efficiency of operations undertaken by the road authority. An objective assessment of activities by the road authority is not possible without a set of adequate indicators. The experience of European countries, as well as of the USA, Japan, Australia, who in mid-90s of the previous century commenced works on creating a system of Road Maintenance Effectiveness Indicators, shows that the process is long-lasting, and requires verification and adjustments of the standards adopted in the international practice to the domestic conditions.

Considering the above premises, three main objectives were set for the present research project:

- To analyse the system of national road maintenance management already applied in Poland and in several selected countries,
- To define the key effectiveness indicators for such a process,
- To indicate the best practices used by foreign national roads authorities, which would contribute to increasing the management effectiveness of national road maintenance in Poland.

1.2. Stages of the Research

To accomplish the objectives set for the project, the research was conducted in four stages:

Stage 1. Survey and selection of Road Maintenance Effectiveness Indicators for the purposes of the research.

Stage 2. Collection of data on the parameters of the national road network, its maintenance management system, expenditure on maintenance works and other data and information essential for the analysis of the road network maintenance management, and preparing the data for a deeper analysis.

Stage 3. Analysing the effectiveness of national road maintenance management in Poland and in selected European countries.

The first part of the analysis identifies the models, standards and practices used in the process of road maintenance management in the divisions of the General Directorate for National Roads and Motorways (GDDKiA). The progress

made in maintenance management in 2010-2011, when the research was carried out is assessed. Further, upon the collected data some selected Road Maintenance Effectiveness Indicators are calculated for national roads in Poland. Unfortunately as the data collected at that time had not been very comprehensive, it was not possible to calculate all indicators defined in the precedent part of the report.

The second part of the analysis is devoted to the basic qualities of road networks, the system of financing and management in countries selected for the analysis: Austria, Czech Republic, England, Germany, Italy and Switzerland. One of the main selection criteria was similarities with the Polish administrative division of roads. Further analysis considers the practices in management of national road maintenance in countries indicated by the recognized international organisations (e.g. OECD/ITF – International Transport Forum) as leaders in the best maintenance practices in road engineering and management. The analysis coveres additionally the USA, Japan, Australia and New Zealand. The purpose of the analysis was, above all, to identify the general trends that serve raising the effectiveness of maintenance not only from the point of view of road authorities, but also from the perspective of road users.

Stage 4. Indicating the best practices on the international scale and formulating recommendations for Poland.

2. Indicators and Research Methodology

2.1. Indicators of Road Maintenance Effectiveness

Definitions of Effectiveness

In the theory of economy and management there are various definitions of effectiveness. Depending on the object, the effectiveness of which is to be assessed, one may speak of effectiveness of the economy, market, sector, enterprise (organisation) or – as in the case of this report – the national road authority. In the PWN Polish Dictionary effectiveness is defined as a "positive result, performance, producing an effect, efficiency, result of business activity defined as a ratio of the effect obtained to the outlay". Effectiveness, however, is not a clear-cut term and measuring it requires a precise definition of the objectives and a selection of appropriate tools.

Effects and outlays may be compared in the economic and technical context. Economic effectiveness means that a given production quantity is achieved by means of the lowest possible costs or financial outlays. On the other hand, technical effectiveness means that the highest possible production quantity is achieved by means of the given production factors. Technical effectiveness is thus a wider term than economic effectiveness. Achieving technical effectiveness is not synonymous with achieving economic effectiveness, either, because economic effectiveness besides the technology of the production process includes also prices of production factors.

Furthermore, in the context of managing transport infrastructure it is necessary to point out the difference between financial effectiveness and socio-economic effectiveness. An analysis of financial effectiveness actually takes into account only the outlays (costs) in terms of financials, that is investment outlays, replacement expenditure and operational (maintenance) costs, whereas the socio-economic analysis – apart from the costs actually incurred – considers also monetised social costs (expressed in pecuniary values), which are not internalised in the financial account (so-called external costs). Thus the socio-economic account includes, for example, costs such as environmental costs or the users' time costs. And thus the technically effective production is not always effective from the economic point of view, and production, which is effective from the financial perspective does not have to be by nature effective from the socio-economic perspective.

On the other hand, in management sciences, effectiveness means a capacity to implement a strategy of an enterprise (organisation) and is an important tool for measuring effectiveness of its activities. Consequently, we can speak of effectiveness in achieving the objectives set or, simply, of management effectiveness. Since the category of effectiveness usually refers to quantities, management effectiveness relates to the ratio of the "as it is" status to the "as it should be" status, that is compares to a certain benchmark (Koźmiński, Piotrowski (ed.) 1997, p. 568). Such benchmark may be defined within an organisation or may include a comparison to the best organisations around. Management effectiveness is also evaluated in a more or less subjective manner by the organisation's customers or other stakeholders. However, such an evaluation is usually not formalised. Evaluation of management effectiveness is of different dimension than the assessment of economic effectiveness and may not be equated with it. However, the evaluation of management effectiveness usually includes elements of effectiveness assessment in socio-economic terms.

Economic Effectiveness vs. Management Effectiveness

Accordingly, economic effectiveness and management effectiveness have both an internal dimension, which is effectiveness seen from the perspective of an enterprise (also called X -efficiency, managerial or technical efficiency) and external dimension, including opinions and satisfaction of customers (users) or in a few cases – their external costs (so-called allocative or social efficiency) (Liebenstein, 1966).

For the purpose of the research topic, the effectiveness of national road maintenance is referred to both effectiveness of activities by individual road authorities and effectiveness of the entire system of finance and public administration, including in particular the existing system of financing the road infrastructure (investment as well as maintenance projects). The present report analyses the effectiveness of the national road authority (GDDKiA) that operates under the specific environmental conditions (legal, administrative, financial and socio-economic). Considerations regarding the administrative division of roads and the principles concerning road finance and budget exceed the objectives of this report.

To measure the effectiveness of management processes, various Performance Indicators (PI) are used, which in reference to road maintenance are often defined as Maintenance Performance Indicators – MPI. The most important indicators are called Key Performance Indicators (KPI).

Indicators of road infrastructure maintenance effectiveness may be divided into three basic groups:

I. **Technical indicators**, also called Asset Performance Indicators (API), which are usually only of a technical nature, but which can also refer to life-cycle pavement costing and combine the technical and economic analysis. Technical indicators in road engineering must not be confused with those performance factors that define the scope of carried-out works and are in fact non-technical indicators. Basic technical maintenance indicators are not indicators of technical effectiveness analysis, either.

II. **Non-technical (operational) indicators**, also called Operational Performance Indicators (OPI), which reflect the operational aspect of road maintenance management effectiveness. As there are many objective difficulties in the socio-economic analysis of road maintenance processes, in the road engineering practice some operational indicators "replace" the socio-economic ones. For instance, the costs of road users due to delays caused by roadworks, which are difficult to estimate, may be replaced with, for example, a time limit for traffic hindrances caused by maintenance works.

III. **Economic indicators,** which consist of financial indicators and socio-economic indicators. In the case of road engineering and management, except for road structures and sections or motorways operated on fully commercial principles (complete revenue and cost calculation), the analysis at the financial level comes down to an analysis of cost effectiveness (due to the lack of revenues the standard financial indicators are usually of a negative value). Indicators of the socio-economic effectiveness are subject to the Cost Benefit Analysis (CBA). However, though CBA is now common in case of investment projects, it is carried out only in a few countries for the purposes of bigger maintenance projects. Indicators based on maintenance costs and outlays reflect the economic aspect of road maintenance management effectiveness.

Analyses of road infrastructure maintenance effectiveness may be carried out at three levels – the technical level, by assessing the parameters of the technical condition of roads, the operational level by assessing the management effectiveness, which is the subject matter of this report, and the economic level, including not only the costs of maintenance, but also road users' costs (table 1).

Table 1. Indicator analysis of road maintenance effectiveness

ASSET PERFORMANCE INDICATORS (APIs)	OPERATIONAL PERFORMANCE INDICATORS (OPIs)	ECONOMIC INDICATORS
– roughness – road evenness – load capacity – depth of ruts – potholes in the pavement – cleanness of the road – other	– output indicators – outcome indicators ▸ pavement condition ▸ quality of travel ▸ traffic hindrances ▸ response time – performance to target indicators	– financial or cost indicators – financing level – socio-economic indicators

Source: own classification.

2.2. Analysis of the Technical Condition of Roads

Technical Indicators

Standard technical indicators for road maintenance refer to the technical parameters of the road and its surface and describe the condition of roads and thereby the technical effectiveness of maintenance. These are:

- **pavement roughness** – the skid resistance properties of the surface. Pavement roughness is one of the main factors improving traffic safety: the higher the roughness, the higher the adherence between the wheel tyres and the rolling surface, and as a result the risk of skidding is lower and the braking distance is shorter;
- **longitudinal and transverse road evenness** – road parameters that are most clearly perceptible by road users. The longitudinal evenness is a quality, which is perceived by the user as the capacity of the road to not trigger quivers and vibrations of the vehicle. Transverse evenness is determined by geometrical deviations of the actual surface in relation to the ideal surface. The evener the road, the higher the riding comfort and the lower the risk of damaging the vehicle. On the other hand, an uneven road provokes an effect of wheels "bouncing" on the surface (in other words – dynamic load effect), which further results in a variable adherence between the wheels and the surface. Improper parameters of transverse road evenness may cause poor stormwater drainage contributing to higher water skid. Moreover, water that fills ruts accelerates deterioration of the surface;
- **load capacity** – thickness of individual pavement layers, which is appropriate for the traffic structure, as well as well-selected building materials, which should have the properties ensuring the durability of layers during the intended period of pavement exploitation. Load capacity is not perceived by road users, but it determines the weight of goods vehicles allowed to the road. Surfaces of roads constructed for higher category of traffic (heavy or very heavy

vehicle traffic) are, in most cases, made of many layers. The higher the load capacity, the higher "resistance" of the road to the traffic of heavy vehicles, which indeed is the major factor contributing to road deterioration. Static axle loads admissible in Poland are 80, 100 or 115 kN depending on the public road category. As vehicles roll on the surface, the dynamic load on the surface is in fact significantly higher than the static load. The dynamic impact of the vehicle on the surface results in a surface-vehicle interaction. The most recent research shows that the impact of heavy vehicles on the surface is of a more aggressive influence than it has been assumed so far (ELLPAG 2009; OECD/ITF 2010);

- **depth of ruts and potholes** – depressions, cracks and potholes in the road surface. The more of them and the bigger they are, the lower the riding comfort and the higher the risk of an accident or damage to the vehicle and – similarly as in the case of unevenness – the higher the risk of accelerated road deterioration (both due to the impact of water and the interaction between vehicles and the "bad" surface).

In case of routine maintenance there are also less complicated APIs, for example the cleanness of the road, and indicators relating to other elements of the right-of-way (e.g. maximum height of grass on shoulders). Well-defined APIs for routine maintenance in connection with performance to target indicators constitute a basis for Performance Based Contracts (PBCs). They are also crucial for controlling the maintenance works performance.

In the context of road infrastructure maintenance management we must bear in mind that the technical condition of the road and its durability before deterioration are hardly predictable. The condition of roads also depends on many factors (cf. Figure 1), on which the road authority has limited influence, e.g. professionalism and due care on the part of designers and constructors, weather and water conditions, as well as parameters of road traffic and drivers' compliance with the road code. The ability to limit the unpredictability of those factors is of key influence for planning and scheduling repavements, including the chance to elaborate stable financial plans.

Table 2. Road condition parameters from the perspective of road users and the road authority

	ROUGHNESS	EVENNESS	LOAD CAPACITY	RUTS AND POTHOLES
For road USERS	means a high riding comfort, the lower the roughness, the riskier the travel	means a high riding comfort, the lower the evenness, the less pleasant and riskier the travel	is not perceptible, should be adjusted to traffic intensity and category of vehicles travelling on the road	mean unpleasant travel and increase the risk of vehicle damage
For the road AUTHORITY	is getting lower in proportion to the volume of traffic; repavement needs are predictable	the longer the road preserves its evenness, the lower the risk of accelerated deterioration and increased repavement needs	traffic of too heavy vehicles causes accelerated road deterioration and unpredictability of repavement needs	road traffic and weather conditions accelerate road deterioration; repavement needs rise

Source: own classification.

Thus the effectiveness of the road condition management in view of the technical road properties depends on at least three key factors:

- qualitative control of design, building materials and workmanship;
- preventing structural maintenance delays, as from a certain critical condition point the deterioration of pavement and other construction elements accelerate. Therefore, the road authority should care to ensure, on an annual basis, appropriate funds in the budget for maintenance works in line with the principle that new investment projects are admissible only after satisfying the need for road repairs and renewals, and not the other way round;
- enforcement of traffic bans on too heavy vehicles (in comparison to the road axle load standard), which however, is beyond the road authority's control as vehicle inspection usually does not belong to his responsibilities. Whether bans are observed or not depends on drivers themselves, the police, Road Transport Inspection Service and other services authorised to carry out inspections.

Figure 1. Factors decisive for the condition of road infrastructure

LIFESPAN OF A ROAD	Each element of road infrastructure is subject to wear during use. Roads must be repaired on a regular basis so that they do not lose their use value. The lifespan of a road is determined by its original technical design. The better the design is adjusted to natural conditions and traffic forecasts, the slower the road deterioration. Good quality of the materials used, as well as good workmanship quality are the condition for preserving the use value of the road in the planned period. Low quality speeds up deterioration and repair needs.
DESIGN AND WORKMANSHIP	
WEATHER AND CLIMATE	The most dangerous natural enemy of roads is water, which not only seeps through the construction elements of the road, but also - by changing the states of matter - causes mechanical damage to the pavement and its foundation. Blobs of water gathering under the surface, by freezing, blast out the surface, which then cracks under the pressure of wheels. Thus, minor damage to the surface becomes the reason for faster technical deterioration of the road. Therefore delays in repairs lead to a more than proportional increase of repair needs. The warmed-up pavement on the road is pressed down by the wheels which causes rutting.
WATER	
TRAFFIC FLOW	The more vehicles roll on the road, the faster the pavement wear i.e. pavement loses on thickness and it becomes smoother. Another effect is the pavement spalling. Heavy vehicles traffic weakens individual pavement layers, causes rutting, unevenness and other pavement failure. The larger the flow of heavy vehicles, the faster the wear and more frequent repair or renewal needs.
AXLE LOADS AND TRAFFIC STRUCTURE	

Source: own description.

2.3. Analysis of Road Maintenance Management Effectiveness

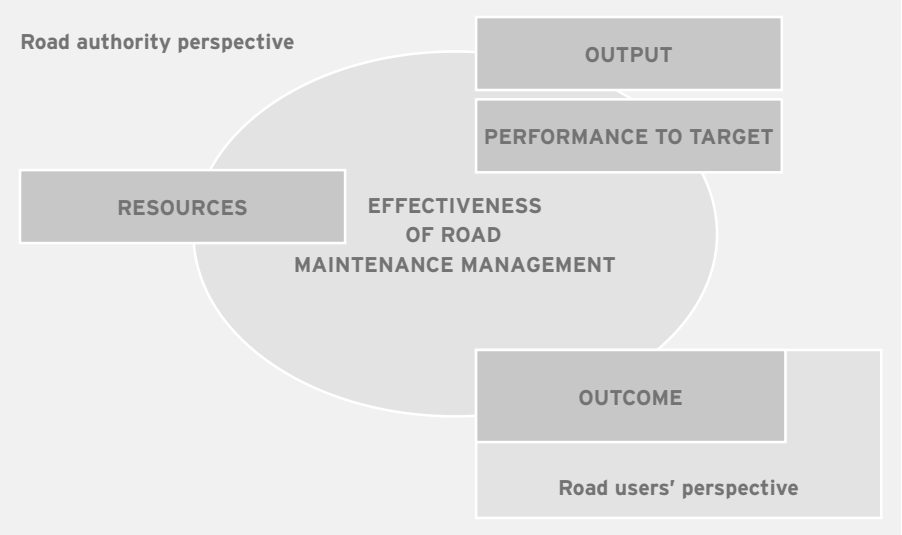
Due to their nature, the non-technical indicators may be defined as operational indicators of road maintenance effectiveness. They may be analysed on at least three levels:

1) central management of the entire road network by the road authority,
2) management of the road network by the road authority local division,
3) management of individual maintenance projects.

As above-mentioned, the indicators should take into account both the road authority perspective and the road users' perspective. When

defining the indicators we must bear in mind that the effort put into the process does not necessarily determine its generally positive perception. For instance, pavement repairs like potholes filling carried out once a season on a large scale in order to obtain a cost scale effect will not receive an applause by the public, if road users had been waiting long weeks for the repairs. Therefore, an analysis of road maintenance management effectiveness refers not only to the activities undertaken and resources used for that purpose, but also to the final result from the road users' perspective.

Figure 2. Perspectives of the road maintenance management assessment



Source: own classification.

On the international scale, there is no coherent set of indicators measuring the road infrastructure management effectiveness. Efforts of international institutions to create a catalogue of assessment indicators (e.g. Performance Indicators for the Road Sector, OECD 2001) focus only on indicating general directions of analyses and usually relate to the entirety of matters concerning the road infrastructure (cf. Appendix C). Only some of them are related to the effectiveness of maintenance management. Individual road authorities create indicators of maintenance management effectiveness for their own purposes. Although similar groups of indicators may be identified, catalogues of indicators applied all over the world differ significantly from each other. Moreover, individual national roads authorities differ as far as the focus of the analysis is concerned. Therefore, for the purposes of this report, the indicators used by selected national road authorities have been juxtaposed and grouped. The selected authorities are:

- the Highways Agency – HA (England)[1],
- Austroads (Australia),
- ASFINAG (Austria),
- Ředitelství silnic a dálnic ČR – RSDCR (Czech Republic),
- ASTRA (Switzerland),
- Azienda Nazionale Autonoma delle Strade – ANAS (Italy),
- New Zealand Transport Agency – NZTA (New Zealand),
- Japanese Road Bureau – JRB (Japan),
- Federal Highways Administration – FHWA (USA).

Road maintenance effectiveness indicators may be presented in three main groups: output, outcome and performance to target indicators.

I. **Output indicators**, simple indicators, e.g. square meter (m^2) or linear meter/kilometre (of e.g. repaved surface) or complex indicators referring to the volume/amount of funds/resources used in the maintenance process (input/output indicators). They are traditional indicators and are commonly calculated by road authorities.

II. **Outcome indicators**, corresponding to customer service indicators in commercial or service companies. In this case road users, that is drivers and their passengers, are the customers. They should not be confused with indicators (barometers) of customer satisfaction based on opinion surveys. They may be both simple and complex. Outcome indicators traditionally communicated to the public are pavement condition and safety indicators. Outcome indicators of pavement condition are based on the technical parameters of road condition and maintenance. The pavement condition from the traditional perspective is presented in a descriptive way by classifying roads into groups of a similar technical condition (e.g. percentage of roads in a good, satisfactory, unsatisfactory or poor condition to the length of the entire road network). If the life-cycle pavement costing is applied, the road surface condition is presented in the context of (residual) value of infrastructure assets. The attention is put only to the threshold that marks exceeding of the defined critical condition, in the case of which structural maintenance is considered necessary or structural maintenance will be necessary in the following budget year.

[1] Wales, Scotland and Northern Ireland have separate road authorities.

Table 3. Outcome indicators related to pavement condition

Indicator
% of network which requires repairs / renewal
% of network where one of the monitored technical parameters exceeded the critical value
% of network which requires strict control of the pavement condition
Forecast % of network which will require maintenance works in the following year
% of network, the pavement of which exceeded the theoretical lifecycle
Residual value of pavement

Source: based on HA reports.

Indicators from the Road Users' Perspective

The shift in the culture of public administrations towards greater transparency and consideration for the increased needs of road users have recently led to extending the catalogue of customer service indicators. The international practice of outcome indicators related to the perspective of road users points out to three groups of indicators:

- **travel quality indicators**, which describe the technical condition of roads and the riding comfort from the perspective of road users (contrary to the indicators of pavement condition from the road authority perspective, cf. previous section);
- **traffic hindrance indicators**, which describe the fatigue or loss of time caused by the maintenance works being carried out; the usage of those indicators is largely connected with the need to take into account the costs of time (delays), which is the basic measurable external effect for the road traffic; therefore, the aim is to limit those losses by restricting the duration and time of roadworks;
- **response time indicators**, which define the time necessary to remove traffic hindrances, e.g. in the case of winter maintenance, after accidents and minor damage to roadway or other accessory infrastructure. Some of those indicators are published in the so-called Road Users' Charter[2] as maximum (or minimum) values of a given indicator, defining the maintenance standard. By compliance with those standards, the road authority takes into account the quality obligation towards road users.

[2] Best practices in this field are discussed in more detail in Chapter 4.3.

III. **Performance to target indicators** referring both to planning and controlling of costs, as well as other issues, e.g. admissible right-of-way exclusions due to carried-out roadworks and the duration of those works, vital from road users' perspective.

Table 4. Indicators of travel quality

Indicator	Comments
– riding comfort (or safe travel, smooth travel exposure), including safe stopping – % of network ensuring riding comfort	With reference to technical parameters, specifies the minimum and maximum of the technical parameter that ensures users' comfort; applied for instance by Austroads and NZTA; should not be confused with road condition indicators.
– travel time/travel time delay/lower speed due to the poor road condition	Delays in travel due to the poor condition of roads expressed in units of time; application only in the case of selected sections of roads; unjustified for the entire network; tested by Austroads and FHWA, applied in JRB as one of the basic road indicators (KPI 1).
– pothole encounter ratio	The number of potholes in the road in relation to transport volume; relatively easy to calculate due to data availability; it may serve the purpose of prioritising works; applied by Austroads.
– % of travel time on pavement covered with snow – % of travel time on pavement covered with water	Applied in Switzerland.
– number of road accidents and incidents or hindrances in traffic as a result of poor pavement condition – number of car repairs and/or average costs of car repairs, which had to be carried out after damage caused by a poor pavement condition	Gathered on the basis of surveys/police reports/ submitted claims; legitimacy of application rises together with effectiveness of road users' claims.
– road cleanness	–

Source: based on documents issued by road authorities in countries selected for the analysis.

Table 5. Indicators of traffic hindrances

Indicator	Comments
– duration of maintenance works on the entire network – alternatively: the duration of right-of-way/road closures	Expressed in hours to km; applied in JRB as one of the basic road indicators (KPI 3). It should be considered as the most restrictive in this group of indicators.
– temporal traffic inspection/temporal closures for traffic on roads with significant intensity of traffic	Expressed in days to km for the entire network applied in HA (BVPI 100)*.
– % of network where roadworks are carried out/where traffic restrictions are put on – alternatively: % of network with traffic hindrances as a result of carried-out works – alternatively: % of available rights-of-way in the network	Specified for the entire network in general or only for business days or only for rush hours; applied in HA (listed in the Road Users' Charter) and by FWHA.
– travel time/delay in travel time/ reduced speed in connection with maintenance works	Delays in travel in connection with carried-out roadworks; expressed in a time unit; applied among others by ASFINAG. It is possible to determine the maximum admissible delay, due to carried-out works, and use it as a basis for the performance to target indicator.
– % of admissions for traffic after scheduled structural maintenance works of which road users were notified in advance	Applied by HA (listed in the Road Users' Charter).
– % of planned maintenance works carried out outside rush hours during the year	Applied by HA (listed in the Road Users' Charter).

* BVPI – Best Value Performance Indicators, applied in the public sector in the UK.

Source: as above.

Table 6. Indicators of response time

Indicator	Comments
– response time after notification of damage to the pavement, lightening defects, etc.	Expressed in hours; applied by Austroads, HA and other authorities.
– number of incidents or notifications of pavement damage which was repaired or secured during 24 hours in relation to the total number of incidents and notifications	Applied in HA (BVPI 105).
– response time for the purpose of reducing delays in traffic after accidents	Applied by many authorities, expressed in a time unit, usually in minutes or hours.
– % of rights-of-way opened within 1 hour after obtaining information from the police on a road accident	Applied in HA (listed in the Road Users' Charter).
– % of the network salted within *X* hours from the occurrence of a snowfall – or % of network salted within 3 hours ahead of the forecast snowfall or ice formation	Applied by many authorities as a performance to standard indicator. Applied in HA (listed in the Road Users' Charter).
– winter maintenance index	An indicator obtained on the basis of a multi-criteria analysis, the aim of which is to define a correct response to the occurrence of specific weather conditions and a comparison of managerial effectiveness, including cost effectiveness of various maintenance units. Difficult to calculate due to problems with data collection (used in many countries, at a phase of application in the Czech Republic).

Source: as above.

Table 7. Performance to target indicators related to scheduled works

Indicator	Comments
– degree of implementing maintenance schedules according to the category of works	Works carried out/works scheduled; expressed in %.
– actual duration of works in relation to the scheduled duration of works – or indicator of work delays	Expressed in % or days; in countries where standards are applied with regard to work duration (e.g. UK, Japan); calculated on the scale of the country and communicated to the public as an indicator of the quality of maintenance works performance (structural maintenance, i.e. repavements).

Source: as above.

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Table 8. Detailed indicators of maintenance targets from the road users' perspective

Indicator	Comments / Detailed indicators
– actual traffic hindrances caused by maintenance works in relation to the respective target	– % of traffic restrictions on rights-of-way (admissible limit of 3%, UK) – % of rights-of-way available for users at peak hours (at least 98.5%, UK) – % of large maintenance works per year, in case of which the length of sections under works does not exceed 4 km and the distance between which is at least 10 km (UK) – % of rights-of-way open for traffic within 1 hour from receiving a formal notification from the police on a road accident (UK) – % of planned maintenance works (refers to less complicated works) carried out outside peak hours in a year (UK) – % of network where the guaranteed distance between work sites is at least 5 km (minimum 50%, ANAS, motorways) – % of network, where works are carried at off-peak hours in the case of short-term works (minimum 70%, ANAS, motorways).
– actual duration of maintenance works in relation to the annual time limit in this respect – time of travel delays caused by roadworks	Calculated for the entire network or individual geographical regions (JRB, KPI 3). E.g. delays in travel time caused by roadworks that are not longer than *X* minutes (ASFINAG).
– actual response time in relation to the respective target of the response time	– % of the national road network salted within 3 hours ahead of the forecast snowfall or formation of ice (UK Road Users' Charter and ANAS, motorways) – % of repairs to the pavement carried out within *X* days from detection/obtaining instructions to fill potholes in the pavement (e.g. 3 days, World Bank specifications) – filling cracks of a width exceeding 3 mm within *X* days from detection (e.g. 7 days, World Bank specifications) – removal of soil, splinters or other obstacles within *X* hours, if there is threat to traffic, and within *X* hours, if there is no threat to traffic (e.g. 1 hour and 36 hours respectively, World Bank specifications) – removal of rubble, debris, branches etc. lying on the road – % of cases of commencing intervention within 3 hours from notification (minimum 85%, ANAS, motorways) – repair of damaged barriers and traffic signs at sites with an increased risk – % of cases of commencing intervention within 24 hours from notification (minimum 85%, ANAS, motorways).

Source: as above.

2.4. Analysis of Road Maintenance Economic Effectiveness

If the road network is not operated on commercial principles[3], and it is not financed out of the road authority revenues only, but public budgets, we can speak of three groups of indicators related to economic effectiveness:

I. **Cost indicators**, where all funds used in maintenance processes should be expressed in pecuniary values as financial expenditure divided into groups or individual items from the catalogue of maintenance works. When juxtaposed with simple output indicators they reflect the costs of the maintenance system. Collected for each of local road service units, they may facilitate cost comparisons and identification of the most effective maintenance units (divisions, districts, etc.).

Table 9. Cost indicators

Indicator	Comments
– costs of individual categories of works	A basic indicator of cost analysis; expressed as: value to unit of output; in case as numerous works are performed it may be difficult to attribute costs to an output unit or even to define the output unit.
– administrative costs in relation to total maintenance costs (OECD PI 11)	Expressed in %; the critical point of analysis is an identification of cost items so that administrative costs are separated from the costs of maintenance works.
– costs of delays caused by roadworks/ maintenance expenditure	An indicator in the test phase only in some countries; due to the work intensive methodology to calculate delay costs, its use is recommended only for selected maintenance projects requiring closure of busy roads; an increase in budget for the maintenance project in order to reduce the time of works results in decreasing additional costs of time (delays) of road users; principles of calculation are the same as in CBA.
– planned costs in relation to actual costs or costs actually borne in relation to planned costs	OECD PI 10, expressed in %; performance to target indicator.

Source: own based on OECD 2001b.

[3] The road authority is not a typical trading company and is not required to submit a financial statement typical for trading companies, and the standard financial indicator analysis does not apply.

Indicators of the Financing Level

II. **Indicators of the financing level**, which gain significance in connection with the problem of accelerated road deterioration resulting from negligence in maintenance. All expenditure considered necessary in a given period, also compared to the actual expenditure as well as renewal delay indicators calculated upon them expressed in monetary terms may be considered as indicators of the financing level. The basis for calculating the necessary level of structural maintenance expenditure is a specified critical value of combined technical parameters defining the road condition. The critical value is chosen from within the range between good and very poor road condition. The objective should be: not to repave roads in a condition that is still acceptable for users, and at the same time not to let the road deteriorate too much to not to generate unnecessary maintenance costs.

Table 10. Indicators of the financing level

Indicator	Comments
– expenditure on routine maintenance and other operational expenses necessary to ensure a certain level of maintenance – expenditure on repavement necessary to ensure a certain level of maintenance	Expressed as value to linear kilometre; an indicator which is relevant from the perspective of financial planning, according to the principle that only available funds should be allocated for new projects after satisfying maintenance needs; applied in many countries, e.g. England, USA, New Zealand, Germany.
– indicator of financing maintenance needs: actual maintenance expenses/ maintenance needs	Expressed in %; shows a deficit in the maintenance budget.

Source: own.

III. **Socio-economic indicators**, which take into account the road users' costs and benefits. Due the complexity of calculations, it is still easier to define time limits on works than to define the work duration as well as financial expenditure plus monetised user costs. However incorporating the socio-economic analysis into long-term investment and maintenance planning gains more and more advocates. Very advanced systems of managing the pavement lifecycle called Pavement Management Systems (PMS) combine the analysis of the technical parameters of roads, necessary level of financial expenditure (investment and maintenance costs) and the user costs (e.g. time costs and vehicle operation costs). The technical effectiveness analysis and the economic effectiveness analysis are combined with each other. The decision on the construction technology and further on the maintenance technology (including intervals between the structural maintenance works) is made upon a calculation embracing actual financial costs as

well as users' costs. Alternative investment (technology) options are compared as to the NPV and other indicators. Only a few national roads authorities carry out this kind of analysis (e.g. in USA).

A juxtaposition of technical aspects of road maintenance, including in particular the issue of the accelerated road deterioration coupled with maintenance costs (internal and external) leads to a conclusion that an analysis of the costs of road maintenance should cover two groups of costs, i.e.:

- financial expenditure on routine and structural maintenance, as well as costs which due to maintenance works are borne by road users. The main user costs, which may and should be taken into account in the cost analysis of maintenance works is the costs of time lost by road users due to hindrances as maintenance works are carried out (e. g. by putting a time limit on roadwork duration);
- additional costs, which must be paid as a consequence of letting roads deteriorate too much. A full analysis of those costs may include additional costs borne by road users, in particular, the increased costs of vehicle operation.

The starting point for a cost analysis is data on resources used in the maintenance process (inputs), i.e. similarly as in case of other economic activities: fixed assets, including machinery and equipment, means of transport at the disposal of the local road service unit, materials used in the maintenance process and the human resources.

However, the inputs as listed above cannot be the starting point for the general road maintenance cost effectiveness analysis. The main reason for this – as in the case of many businesses – is the outsourcing of many maintenance works. In Poland, and in other countries, maintenance works are usually outsourced. Yet in the field of routine maintenance there is no uniform practice – there are models of both insourcing, and outsourcing, as well as mixed models. A comparison of cost effectiveness of insourced maintenance with outsourced maintenance comes down to a comparison of own costs with prices "negotiated" in a tendering procedure. We should also bear in mind that contractors may be more cost effective as they do not bear some of overhead costs.

A detailed division of inputs used in maintenance processes (routine maintenance) is useful when making comparisons between the own maintenance units. However, some problems may arise as the same people carry out many tasks using the same equipment. It may be difficult to disaggregate the calculation into individual items of the maintenance works catalogue. Cost calculation of individual items of the routine maintenance catalogue even with reference to costs borne to carry out a specified task will be error-burdened.

Road Users' Costs

Road users usually do not examine the costs of vehicle operations as per different road condition or the costs of time lost because of maintenance works. Their assessment is subjective and not formalised. Nevertheless, there are formalised systems of calculating road users' costs. Different methodologies to monetise costs as well as different factors taken into account in the analysis lead to various values of road users' costs. Various CBA textbooks/instructions contain different cost levels. In Poland, in a formalised assessment of investment projects to be financed out of EU funds, cost levels are applied from the JASPERS Blue Book – Road Infrastructure.

The vehicle operation costs depend, among others, on the vehicle speed and the slope of the road. However, for the same parameters of travel but different road conditions, vehicle operating costs differ less than 0.10 PLN for passenger cars and more than 0.10 PLN for trucks per every kilometre of travel (table 11).

The costs of time spent on the road when travelling depend on the travel purpose. They are the highest in the case of business trips and the lowest in the case of trips for leisure. They are calculated on an annual basis as they depend among others on the average pay. To analyse costs incurred by roadworks we take into account only the difference between the standard travel time and the travel time with traffic hindrances (table 12).

Table 11. Vehicle operating costs on a deteriorated and new pavement (PLN/km)

Speed	PASSENGER CARS		TRUCKS	
	Deteriorated pavement	New pavement	Deteriorated pavement	New pavement
10 km/h	1.231	1.166	3.740	3.559
20 km/h	1.197	1.150	3.638	3.488
30 km/h	1.170	1.137	3.560	3.434
40 km/h	1.150	1.126	3.508	3.298
50 km/h	1.136	1.117	3.480	3.379
60 km/h	1.128	1.111	3.478	3.378
70 km/h	1.124	1.108	3.513	3.402
80 km/h	1.126	1.108	3.548	3.427
90 km/h	1.131	1.111	3.620	3.478

Source: JASPERS (2008).

Table 12. Costs of one hour spent travelling by car (PLN/hour)

Year	Business Trips	Commuting	Other
2011	58.44	29.30	24.16
2012	60.92	30.66	25.18
2013	63.49	32.08	26.24
2014	65.93	33.46	27.26
2015	68.51	34.88	28.31

Source: JASPERS (2008).

Though driving on a deteriorated road is of low economic significance (in contrast to the road users' perception as it can be significant, particularly in case of suspension damage), long lasting roadworks entail huge losses of time in monetary terms for the entire economy, even if they extend the travel time of one person by only ten minutes per day.

2.5. Benchmarking and the Best Practices

Benchmarking is a tool helping organisations to increase the effectiveness of their activities, and under the market conditions also to increase the competitive advantage. It is a method or a process of a continuous systematised comparisons to organisations in a given industry and then "equalling oneself" to the leaders by learning from them and using their experience. The improvements may concern: products or services, processes, methods of management, organisational structures, or their elements. The best organisation, product or process constitutes a benchmark – a model, a specific point of reference.

However, the essence of benchmarking is not to find and transfer ready-to-apply patterns, but the manner of arriving at the best practices using the experience of others simultaneously adjusting to the purposes of own organisation.

Kinds of Benchmarking

We can distinguish between the internal and external benchmarking. External benchmarking concerns comparisons to entities outside an organisation, e.g. competitors in the same market segment or other entities whose operations may – to a certain extent – be interesting from the point of view of our organisation. However, we should bear in mind that due to specific features, tasks and objectives of a government entity (i.e. the national roads authority), the methods and tools to assess the management effectiveness commonly used in commercial organisations, i.e. for-profit organisations, may not be directly applicable in public administration (Ziółkowska 2009, pp. 75-83).

Internal benchmarking means comparing performance by different units of the same organisation. This type of benchmarking focuses on examining and assessing the processes and methods used in a given division or department of an organisation in comparison to other divisions or departments. The disadvantages of internal benchmarking include its narrow perspective and prejudice that may arise in the organisation.

Besides comparisons between entities, we may benchmark results achieved by the organisation using a number of indicators measuring the corporate effectiveness, both in the financial and economic aspect, as well as the operational aspect. On the other hand, benchmarking of best practices refers to comparing processes, which in themselves are examples of best practices.

All commonly known types of benchmarking (among others internal, competitive, strategic, processes, results, best practices) may be applied to the assessment of road maintenance management effectiveness.

Limitations of Comparative Analysis

On the international scale, it is not possible to compare quantitatively the road maintenance practices of national roads authorities active in different political and administrative/legal systems. The problem of quantitative comparisons lies in differences in network size and road categories, including applied maintenance standards, road technologies and the cost levels of works and management in individual countries (the problem of cost of labour in particular). One of the objective reasons that make comparisons impossible is different classification of works in main cost categories. Though, in the case of routine maintenance the catalogue of works practically does not differ in individual countries. However, in the case of structural maintenance we deal not only with repavements, but also with renewals complemented by upgrading works. Due to the long lifespans of road infrastructure elements, it seems reasonable to carry out upgrading works aimed at increasing the load capacity at the moment as the existing top surface layer (so-called wearing course) requires repavement, but not earlier. Therefore, international comparisons of road maintenance practices are limited to benchmarking of the best technological, organisational and other practices.

Comparisons within a national road organisation are easier. It is possible to make a quantitative comparison of local divisions and districts. However, depending on the objective the methods of the benchmarking analysis must be adequate: from one-dimensional indicator analysis to multi-dimensional border analysis (non-parametrical and parametrical analysis). One of the methods, which may be applied to a comparative analysis of operational effectiveness by individual units of the same organisation is a multi-criteria input/output analysis, e.g. DEA (Data Envelopment Analysis). Due to the lack of coherent and complete data concerning inputs and outputs for regional divisions of GDDKiA, conducting a DEA analysis for the purpose of assessing the effectiveness of GDDKiA's operations is not possible yet. However, the new principles of collecting and storing maintenance data currently introduced will make DEA analysis possible in the coming years.

3. Effectiveness of National Roads Maintenance Management by GDDKiA

3.1. The National Road Network

National Roads in Poland

At the beginning of 2011 the overall length of public roads in Poland was 406,100 kilometres, out of which paved roads constituted approx. 67%. The length of national roads was 18,600 kilometres, including over 1,500 kilometres of high-speed roads (857 km of motorways and 675 km of expressways). The average density of national roads was 5.9 km per 100 km^2 and 48.7 km per 100 thousand inhabitants. There are over 4.3 thousand bridge structures on the national road network.

National roads, which constitute about 4.6% of the length of the public road network, carry over 60% of the total traffic. As far as the impact on the technical condition of pavement is concerned, the most significant factors are: annual average daily traffic (AADT) measured by the number of vehicles passing daily through the cross section of a road, daily traffic volume measured by vehicle-kilometres and the traffic structure, measured by the relation of light vs. heavy traffic (trucks with or without trailers).

Annual Average Daily Traffic (AADT)

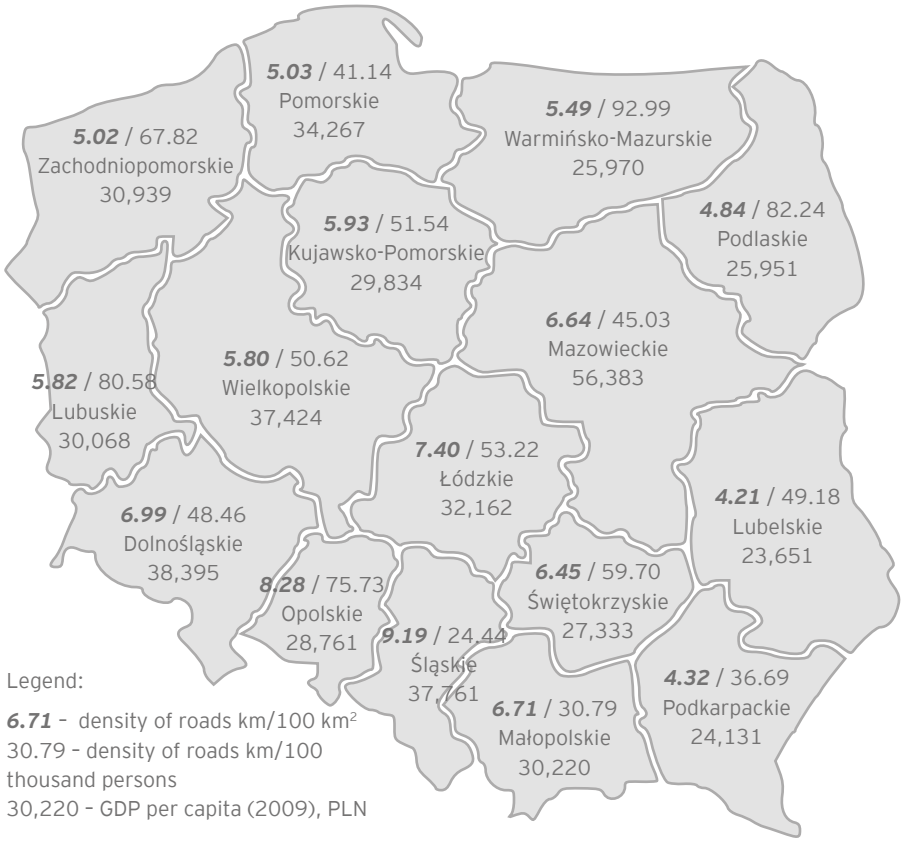
According to the results of the latest general traffic census (GPR 2010), the average daily traffic of motor vehicles in 2010 on the national road network was 9,888 vehicles daily, which marks an approx. 22% increase in comparison to the census of 2005[4]. The traffic burden is not equal on the entire network, but it increases in line with the growing significance of roads. On the international roads the average daily traffic in 2010 was 16,667, whereas on the remaining national roads it was 7,097 (see Appendix D, table 2). In comparison to the census of 2005, in all voivodships an increase in traffic was recorded, with the highest increase amounting to over 30% in Śląskie, Pomorskie and Opolskie. The lowest increase in traffic (about 15%) was recorded in Zachodnio-Pomorskie, Lubuskie and Warmińsko-Mazurskie, i.e. voivodships where AADT in 2010 was much lower than on the entire national road network (Synthesis of GPR Results 2010, Transprojekt-Warszawa 2011).

[4] General traffic census in Poland is carried out each five years.

Due to the geographic location, historical determinants, as well as the industrial and commercial potential, and the level of socio-economic development of individual voivodships there is an essential regional discrepancy between the length and density of the national road network and the road traffic load (cf. Figures 3 and 4):

- The voivodships in southern and central Poland are best equipped with road network, in particular: Śląskie, Opolskie, Łódzkie, Dolnośląskie, Mazowieckie, Małopolskie and Świętokrzyskie, where the density of roads measured in kilometres per 100 km^2 of the voivodship area, is larger than the national average. Meanwhile, only in three out of these voivodships the GDP per capita was higher than the country average;
- The Mazowieckie Voivodship, which is the richest in terms of GDP and has the longest network of national roads, is characterised by geographic density of the network at the level of national average with density of roads per 100 thousand inhabitants slightly lower than the national average; the traffic volumes are the highest in Poland (measured in vehicle-kilometres), both by trucks and passenger cars;

Figure 3. GDP per capita and the density of national road network in voivodships (2010)

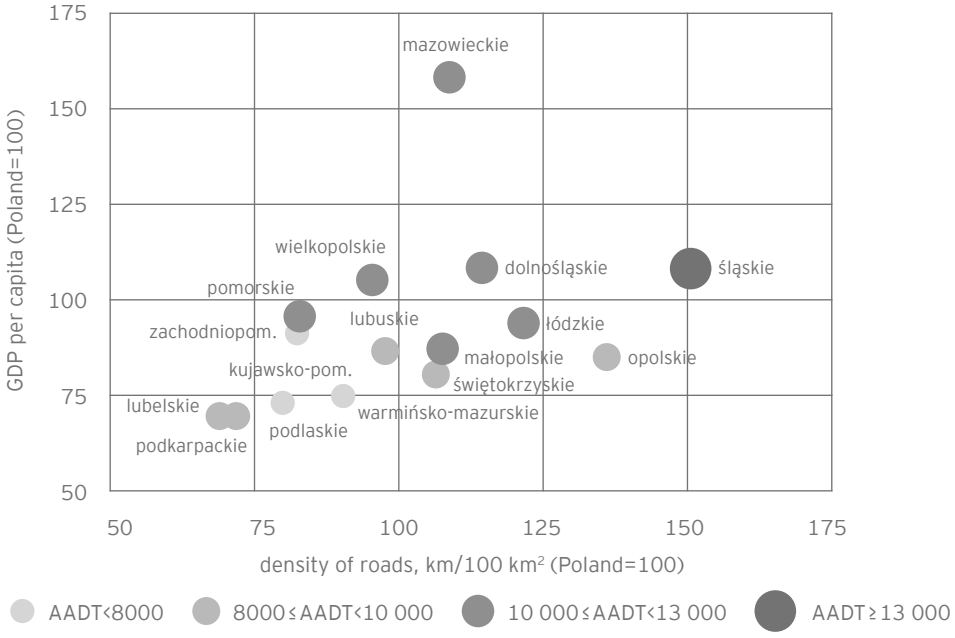


Legend:

6.71 – density of roads km/100 km^2
30.79 – density of roads km/100 thousand persons
30,220 – GDP per capita (2009), PLN

Source: based on data by the Central Statistical Office (GUS).

Figure 4. GDP per capita, density of national road network and AADT in voivodships



Source: based on data by the Central Statistical Office and GPR 2010.

- the Śląskie Voivodship, which is the second in Poland in terms of the GDP value and population, precedes several voivodships as to the length of national roads (Wielkopolskie, Łódzkie, Dolnośląskie, Warmińsko-Mazurskie), however it has the densest road network per 100 km^2 of the area (9.2 km) and, at the same time, the lowest density (24.4 km) per 100 thousand inhabitants. In this voivodship, the AADT is the highest and amounts to 18,262 vehicles daily (32% more than in 2005), and in the international traffic almost 35,700 vehicles daily. The heavy traffic load is high, and comparable to that in Mazowieckie and Wielkopolskie voivodships;
- the average daily traffic of over 11,000 vehicles was recorded in 2010 in Małopolskie, Łódzkie, Dolnośląskie, Mazowieckie and Wielkopolskie. The lowest traffic on the national road network, below 7,000 vehicles daily, characterises Warmińsko-Mazurskie and Podlaskie, which have low national roads density (below 90% of the national average) and GDP per capita at the level of approx. 74% of the national average). In two poorest voivodships – Podkarpackie and Lubelskie – with the shortest road length, density per km^2 and a small proportion of heavy vehicle traffic, the average daily traffic in 2010 constituted respectively 97% and 75% of the national average;

- the highest density of roads per 100 thousand inhabitants characterises Warmińsko-Mazurskie, Podlaskie, Lubuskie and Opolskie, where the road networks are not overloaded with traffic.

The steady increases in traffic of trucks with trailers in recent years is of significance for the present analysis, as it influences decisively traffic conditions on the roads as well as the process of pavement wear. In 2005-2010, the traffic of trucks with trailers increased by approx. 43%. In previous five-year periods an increase in the traffic of those vehicles was however higher and amounted to 68% in the years 1995-2000 and 50% in the years 2000-2005. This amounts to the total of over 3.5-times increase in the traffic of trucks with trailers in the recent 15 years, whereas traffic increases in absolute numbers in successive five-year periods were higher each year (GPR Results 2010, p. 12). In the context of heavy vehicle traffic, which grows continuously, a vital problem in Poland is insufficient load capacity of many national roads not suitable for vehicles with axle load of 115 kN, which is the basic standard for the international road network in Europe. Although from EU accession to the end of 2010 the share of roads fulfilling this standard increased from 5.1% of the total length of the national road network to over 31% (approx. 5.9 thousand kilometres), insufficient load capacity on the remaining 2/3 of the national road network generates additional costs of road maintenance.

In accordance with the provisions of the new Scheme for Construction of National Roads, the process of adapting the national road network to axle loads of 115 KN on the main transit routes should have been completed by 2015. However, it must be considered that due to budgetary constraints only the most urgent projects will be completed with priorities put on roads with the highest long-term forecasts of heavy vehicle traffic.

3.2. The System of National Road Maintenance Management

The system of national road management in Poland is historically related to the administrative division of the country. Under the new administrative system from 1 January 1999 Poland is divided into: 16 voivodships [*województwa*], 373 counties [*powiaty*] (including 308 rural counties and 65 cities on county rights), as well as 2,489 urban and rural municipalities [*gminy*]. The public road network was adjusted to the new Polish administrative system and according to the function fulfilled it was divided into the following categories: national roads, constituting the property of the State Treasury, as well as voivodship, county and municipal roads constituting the property of local governments at the relevant level.

The authority responsible for the national roads (excluding sections of national roads within the boundaries of 65 cities on county rights, including the capital city of Warsaw, in total approx. 1,400 km), as well as motorways and expressways (excluding tolled motorways managed by concessionaries), i.e. in total approx. 17,000 km of roads, is the General Director for National Roads and Motorways.[5]

GDDKiA Organisational Structure

The General Director fulfils his tasks with the assistance of the General Directorate for National Roads and Motorways (GDDKiA), which consists of the head office and 16 regional divisions territorially overlapping with voivodships. GDDKiA is the national road administrator or authority. The organisational structure of the GDDKiA head office is presented in Figure 5. The Road and Bridge Management Department organises the process of planning, designing and carrying out upgrading works, renewals, maintenance and protection of roads and road structures, technology of bridge works and controlling the road service units.[6]

The Department consists of: Road Management Department, Bridge Management Department, Department of Administrative Proceedings, Team for Co-ordinating and Monitoring Road Works, Consultative Team, Chief Road Inspector, Chief Bridge Inspector.

Tasks related to road maintenance are strictly connected with traffic safety management (Traffic Safety). One of the most essential changes in the organisational structure of GDDKiA introduced in 2010 was the setting up of the Traffic Management Department, which was

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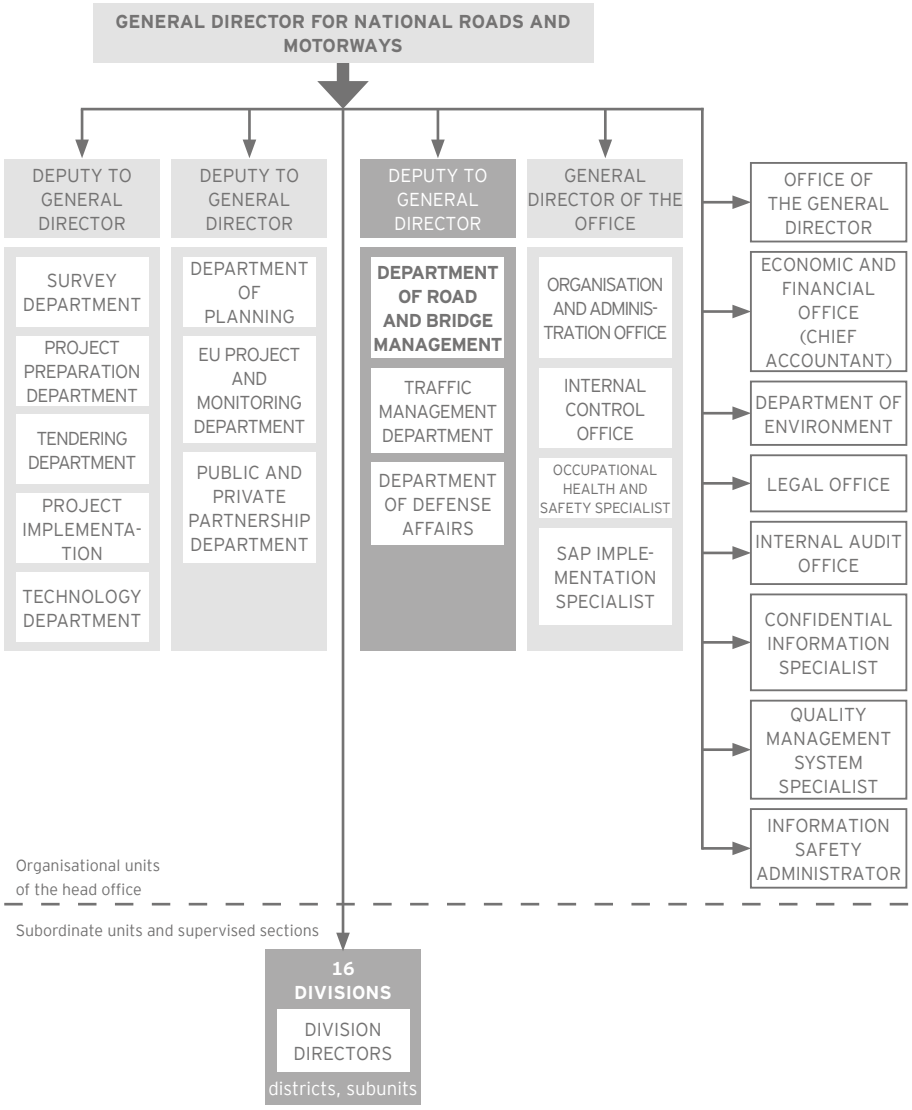
[5] Article 18 par. 2 of the Act dated 21 March 1985 on Public Roads, Journal of Laws Dz. U. of 2007 No. 19 item 115. Consolidated text.

[6] §18 of GDDKiA Organisational Rules, Order no. 26 of 20.04.2010, contains a detailed list of tasks of the Road and Bridge Management Department.

entrusted with organisational and technical matters of planning, designing and carrying out projects in the field of traffic management, traffic engineering and improvement of road traffic safety on national roads.

Figure 5. GDDKiA Organisational Structure



Source: based on the Appendix no. 2 to Order no. 26 dated 20.04.2010 (GDDKiA).

GDDKiA regional divisions are responsible for administration, maintenance and upgrading of the network of national roads, motorways and bridges. Each division is headed by a division director leading a team of deputies responsible for individual departments (particularly road, planning, and investment projects department). Divisions have local offices, called road districts, directly responsible for the condition of network on their territory. In general, at the beginning of 2009 in 16 GDDKiA local divisions there were 106 districts with 275 subunits, employing nearly 3 thousand people. Practically, in the last two years the number of districts has not changed (105), whereas the number of subunits increased to 286. Districts operate the so-called material and equipment depots, as well as centres of winter maintenance.

IT Suport for Road Maintenance Management

Over many years GDDKiA created several systems for collection and filing data on the road network and condition indispensable for systematic management of the road maintenance process. From 1989 a computer System for the Assessment of Pavement Condition (*System Oceny Stanu Nawierzchni* – SOSN) is being developed based on systematic measurements of technical and exploitation features of asphalt pavements such as: cracking, longitudinal evenness, ruts, pavement condition, anti-skid properties (roughness). In 2007 the guidelines for the System for the Assessment of Concrete Pavements (*System Oceny Stanu Nawierzchni Betonowych* - SOSN-B) were introduced. On the other hand, a tool serving the purpose of managing, collecting and recording data on road structures is the System for Bridge Management (*System Gospodarki Mostowej* – SGM). In addition, a System for the Assessment of Shoulders and Road Drainage Components (*System Oceny Poboczy i Elementów Odwodnienia Dróg* – SOPO) is in use since 2006. Data collected in the above-mentioned systems makes it possible to clearly assess the backlog in repairs of the assessed road construction elements and to earmark funds for routine maintenance.

The system supporting the management of the national road network is the Road Data Bank (*Bank Danych Drogowych* - BDD), which was designed as a group of relational databases, fulfilling a number of functions like recording and editing information on the road network condition. This system contains not only numerical or descriptive data, but also data related to the road network: linear plans, cross-sections of roads, schematic diagrams of interchanges, digital maps of various scale and content, multimedia data (photographs of the right-of-way, aerial photographs, video-registration). The data is used for the purposes of routine maintenance of roads, preparation of new investment projects, as well as reporting, filing and control.

The pavement condition indicators together with the traffic census results (GPR) and the long-term traffic forecasts, as well as accident statistics[7] constitute the basic input parameters for the detailed planning of road renewals in each local division (see Figure 6).

Identification and prioritisation of national roads sections requiring renewals is possible with the assistance of the Highway Development and Management (HDM-4) computer system, which is based on measurable technical and economic parameters. This instrument was developed as part of the renewals project financed by the World Bank loans. The system combines algorithms serving simulation and automation of calculations with extensive experimental database on interdependencies between pavement deterioration, maintenance costs and users' costs, that can be analysed for various maintenance alternatives and design characteristics. If used to the full extent, the system facilitates quite advanced technical and economic analyses of the PMS standard. However, the lack of a stable and predictable system of financing the national roads maintenance in Poland makes it impossible to fully use this system in order to identify and prioritise road sections requiring renewals as well as select structural maintenance operations, which would be optimal as far as pavement lifecycle is concerned. Thus, instead, the actual Renewal Programme for the years 2011-2013 was prepared on the basis of data on road sections requiring renewals collected from GDDKiA divisions and sorted out by urgency.

Funds allocated amongst individual divisions for structural maintenance in a given year are divided upon evaluation methodology prepared by GDDKiA in cooperation with the Road and Bridge Research Institute (IBDiM). The methodology is based on the following assumptions:

- 70% of outlays in proportion to the length of the road network requiring immediate renewals (that is a network in a poor condition);
- 20% of outlays in proportion to the length of paved road network multiplied by average heavy vehicle traffic;
- 9% of outlays to be divided among voivodships, where the indicator of pavement needs is above 0.3;
- 1% of outlays is divided among divisions, within the area of which there are road sections with concrete pavement (excluding new sections and those, which are undergoing renewals).

Exchange of data is possible between individual systems used in GDDKiA, however up to now mainly technical parameters have been collected and analysed to describe the road construction elements and other auxilliary facilities, together with maintenance data, describing for example the road surface condition or traffic flow. Data concerning

[7] The source of data on accidents are reports on traffic incidents drawn up by the police on site.

expenditure on individual maintenance works was collected by means of standard spread sheets or by means of BUDWIN and ZIMAWIN software. The collected data on operations undertaken in individual divisions was not always complete and coherent. High level of aggregation made it impossible to conduct a complex managerial analysis. Therefore, it was neither possible to analyse maintenance effectiveness, nor to control cost (fields marked with dark grey in Figure 6). Activities undertaken over two recent years, such as for example implementation of a new class of software, will improve the situation in this field.

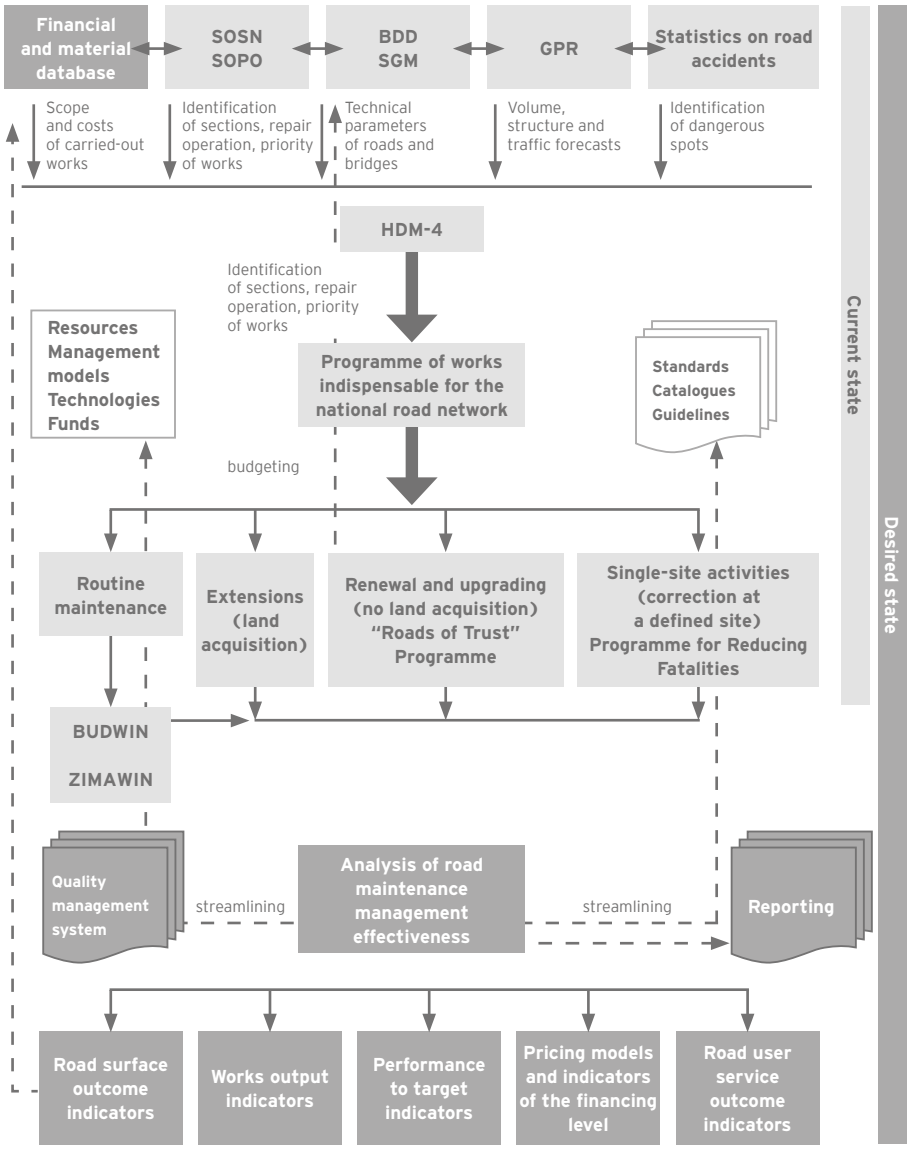
Models of Maintenance Management

Another important element of the management system are standards and applied models of managing the road network maintenance. The process of maintenance management in individual GDDKiA divisions is currently organised either as:

- **mixed insourcing and outsorcing scheme** – works are partially insourced (as far as own resources and funds will allow) and partially outsourced; or
- **outsourcing scheme** – works are outsourced to other entities by way of tenders. Selected contractors, using their own resources, or with the assistance of subcontractors using their own materials and equipment, carry out services and construction works on the roads. The main factor determining complexity of outsourced maintenance works is availability of contractors in a given region. The role of the road authority in routine maintenance comes down to defining requirements related to maintenance, including maintenance standards, planning, supervision over carried-out works, as well as approval and settlement of works[8].

[8] The outsourcing model is also used by municipal road authorities, who are responsible for maintenance of national roads sections located within the boundaries of cities on country rights, which are not subject of the present research.

Figure 6. National road network management system



Source: own based on GDDKiA's materials.

Table 13. Models of performing maintenance works in GDDKiA divisions (as of March 2011)

Voivodship	GDDKiA division	Model of performing maintenance works		Number of contractors in a region	
		mixed	outsourced	small	sufficiently high
Podlaskie	Białystok	■			■
Kujawsko-pomorskie	Bydgoszcz		■		■
Pomorskie	Gdańsk		■	■	
Śląskie	Katowice	■			■
Świętokrzyskie	Kielce		■		■
Małopolskie	Kraków		■		■
Lubelskie	Lublin		■		■
Łódzkie	Łódź	■			■
Warmińsko-mazurskie	Olsztyn	■		■	
Opolskie	Opole	■		■	
Wielkopolskie	Poznań		■		■
Podkarpackie	Rzeszów	■		■	
Zachodniopomorskie	Szczecin		■	for ZUD	■
Mazowieckie	Warszawa		■	■	
Dolnośląskie	Wrocław	■			■
Lubelskie	Zielona Góra		■		■

Source: own based on GDDKiA information.

Performance Based Contracts (PBC)

The target model of maintenance management is total outsourcing of all works on a specified part of the network or a road section to one external company, whereas the subject of assessment and approval is only compliance with work standards specified in the contract. This model is based on final outcome and not on activities leading to this outcome. Adopting such an approach requires development of uniform standards for road maintenance both in terms of technical parameters and leadtime limits, upon which long-term performance based contracts (PBC) are signed. In this respect, in 2010 for the first time the "Keep Up with the Standard" model was applied to two newly-built sections of S3 expressway and a four-year contract was signed with a contractor selected in an open tender procedure (example in the box below). In August 2011 two more invitations for tenders were published for comprehensive maintenance of A2 motorway on the Konin-Dąbie section and the Wrocław Ring Road (Autostradowa Obwodnica Wrocławia – AOW).

"Keep Up with the Standard" maintenance contract on the S3 Klucz-Myślibórz expressway[9]

The Szczecin-Gorzów Wielkopolski section of the S3 expressway (81.6 km) is a newly constructed road in the corridor of the planned A3 motorway. In May 2010 the Klucz-Pyrzyce section was put into service, followed by the Pyrzyce-Myślibórz section at the end of October.

Technical parameters of the S3 Klucz-Myślibórz expressway

Length	54 km	Width of median strip	4.00 m
Viaducts	53	Width of emergency lane	2.50 m
Culverts	102	Width of soft shoulder	0.75 m
Design speed	100 km/h	Side slope	1:3 ÷ 1:1,5
Width of traffic lane	3.50 m	Vertical clearance	4.70 m
Number of traffic lanes	2 x 2	Axle load	115 kN

In an open tender published on 31 August 2010 only one bid by Maldrobud was submitted. Under the contract signed with GDDKiA, from 1 December 2010 Maldrobud assumed responsibility for complete maintenance of the Klucz-Myślibórz section for four years. The value of the contract is PLN 51 million. The Contractor receives a monthly lump-sum remuneration. His obligations include among others:

- road inspection rounds every two hours between 6.00 a.m. and 6 p.m., and every two hours at night;
- pavement maintenance, pothole filling with patch or other technology;
- winter maintenance: snow removal, anti-skid measures on the road, including slip roads, travellers' service areas (MOPs), as well as viaducts over the expressway;
- keeping the carriageway and the right-of-way clean, as well as entrances and exits, agricultural passages and emergency lanes;
- keeping the technical equipment of the expressway in a good technical condition so that there is no risk to traffic safety, and ensuring proper operation of all road elements;
- maintenance of traffic signs and guideposts, as well as replacing them on an ongoing basis (in the case of damage, theft, etc.);
- maintenance of road surface markings – replacing missing marks (as the need may be);
- maintenance of roadside greenery – lawns, trees and shrubs;
- maintenance of slopes and embankments – filling in missing parts and repair after collisions and atmospheric phenomena;
- maintaining and providing additional equipment facilitating better road management;
- cooperation with the road authority, Police, rescue services, units of the Emergency and Fire-fighting System.

[9] Based on GDDKiA materials.

Examples of deadlines for works performance and penalties for failure to meet the deadline

Type of works	Deadline for works performance	Penalty points*
Elimination of a bump posing a traffic threat	4 hours	5
Minor repairs to the roadway	4 hours	1
Filling in missing parts of shoulders	3 days	1
Mowing the right-of-way lane (height of grass at max. 15 cm)	7 days	1
Replacing road signs	4 hours	5
Replacing road surface markings	3 days	5
Liquidation of braking traces on road surface markings	2 days	1
Replacing and securing a site where the guardrail is damaged	72 hours	5
Replacing manholes and catch basins grates	2 days	5
Repairs of fencing	24 hours	2
Removing dangerous objects and dead animals	2 hours	5

* One penalty point = PLN 500.

According to GDDKiA initial estimates, the costs of road maintenance at a similar standard based on the mixed insourcing-outsourcing system and on a fully contracted-out basis applied on the S3 road are similar, or lower if the higher standard is ensured by comprehensive maintenance contracts as the road authority does not need to hire additional employees, thus bears lower costs. This model should facilitate a gradual introduction of the life-cycle pavement costing on new road sections.

The table below contains a synthetic presentation of changes made by GDDKiA since 2010 related to national roads maintenance, including standards for routine maintenance.

Table 14. Changes to the management system of national roads maintenance

Element of the management system	State before 2010	Changes in 2010	Changes in 2011
Model of the maintenance system	Outsourcing or mixed insourcing and outsourcing.	Two long-term contracts on a "Keep-Up with the Standard" basis concluded. The system of road maintenance analysed and an internal report prepared.	The scope of outsourced works extended. More "Keep Up with the Standard" contracts concluded.
Standards for routine maintenance:			
- for roads	No uniform standards for the entire network.	New Catalogue of Maintenance Works elaborated. Road maintenance standards defined. A catalogue of temporary traffic organisation elaborated. Guidelines for road inspection rounds elaborated. A plan for routine control of the road condition elaborated.	The Catalogue of Maintenance Works updated. Standards for road auxiliary facilities elaborated. Uniform standards for road maintenance management elaborated.
- for bridges	No uniform standards for the entire network.	A new Catalogue of Maintenance Works for road structures elaborated.	A catalogue of typical bridge structures elaborated.
Data collection and storage	Selected data compiled in Excel spread sheets. A table for monitoring the routine maintenance of road network (Excel spread sheets, 2007) elaborated.	Bank of road data (technical parameters) established. BUSD monitoring table updated. BUDWIN and ZIMAWIN software implemented.	Integration process of databases initiated.

Element of the management system	State before 2010	Changes in 2010	Changes in 2011
Assessment of the surface condition	SOSN, SOPO, SOSN-B, SGM systems in use. Measurements held once per year. A report on surface condition published in March. Indicator of immediate repavement needs.	Report for the year 2010 for the first time presents comprehensively the technical condition of the national road network (not only surfaces).	Penetrating radars to recognise and monitor the surface condition introduced. Measurements twice a year introduced.
Budgeting (earmarking of financial means)	Algorithm and measures prepared together with IBDiM. Use of HDM-4 system to prioritise sections of roads requiring repavement.	Renewal programmes for the years 2011-2013 and works which are indispensable for the network on the basis of data collected from divisions prepared.	
Reporting	Only obligatory reports (by law), i.e. reports submitted to GUS (Central Statistical Office) and NIK (Supreme Audit Office).	Basic annual results presented in the form of PowerPoint presentations, available in PDF at the web site.	No essential changes introduced.
Monitoring effectiveness of maintenance management	For the purpose of single analyses, calculation of selected output indicators, outcome indicators related to surface condition, single performance to target indicators.	No essential changes introduced.	No essential changes introduced.

Source: own classification.

3.3. Indicator Analysis of the National Roads Maintenance Management Effectiveness

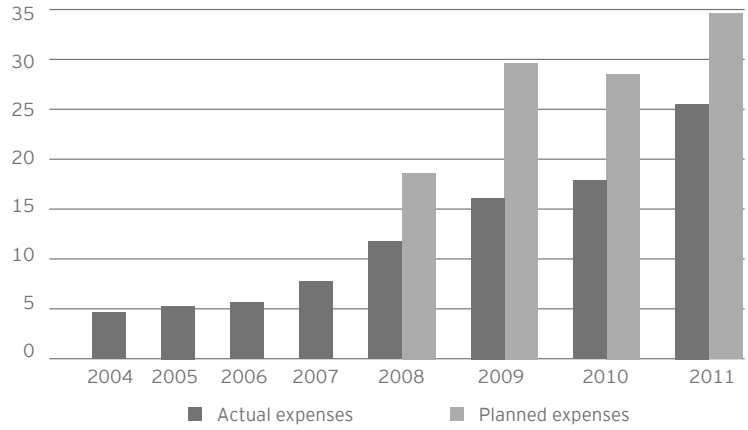
3.3.1. Financing Level and Cost Indicators

GDDKiA as a government agency funds the routine maintenance of the national road network out of state budget means, including, to a small extent however, funds from the special purpose National Road Fund (*Krajowy Fundusz Drogowy* - KFD). As far as repavements and renewals of roads and road engineering structures are concerned, additional funds are raised through loans and credit facilities of international financial institutions.[10]

While analysing the level of financing of the national road network, we have to distinguish between expenditure on investment projects (capital outlays) like construction and modernisation (upgrading) of roads, and the expenditure on road maintenance and repairs (the so-called current expenses). Though investment outlays are not the subject matter of this report, the basic data on investment, routine maintenance and structural maintenance funding may throw some light onto the differences in financing levels.

In the years 2004-2011 nearly PLN 96 billion was invested into the construction and upgrading of the national roads in Poland, and in 2011 the investment spending achieved a record level so far (PLN 26.4 billion). A significant increase in outlays in the recent three years was possible as the Programme of National Road Construction has been carried out on a large scale. However, the actual expenses in the years 2008-2011 constituted only 64% of planned investment assumed in the Programme.

Figure 7. Investment expenditure on the development of the national road network (PLN billion)

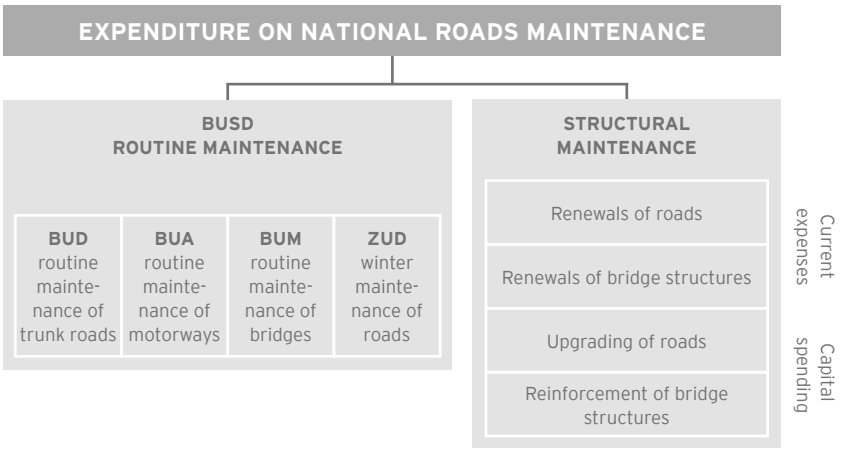


Source: based on GDDKiA data.

[10] In the years 2004-2008 these were loans of the World Bank and credit facilities of the European Investment Bank.

Expenses on maintenance of the national road network include expenses on routine and structural maintenance (renewals and upgrading) of roads and bridge structures (see Figure 8). Routine maintenance of roads includes: pavement repairs, maintenance and conservation of traffic signs and traffic safety facilities, drawing and conservation of road surface markings, maintenance and replacement of greenery, as well as keeping roads clean. As for winter maintenance the scope of works includes anti-skid measures, removal of snow from the carriageway and footways, etc.

Figure 8. GDDKiA expenditure on national roads maintenance by works category

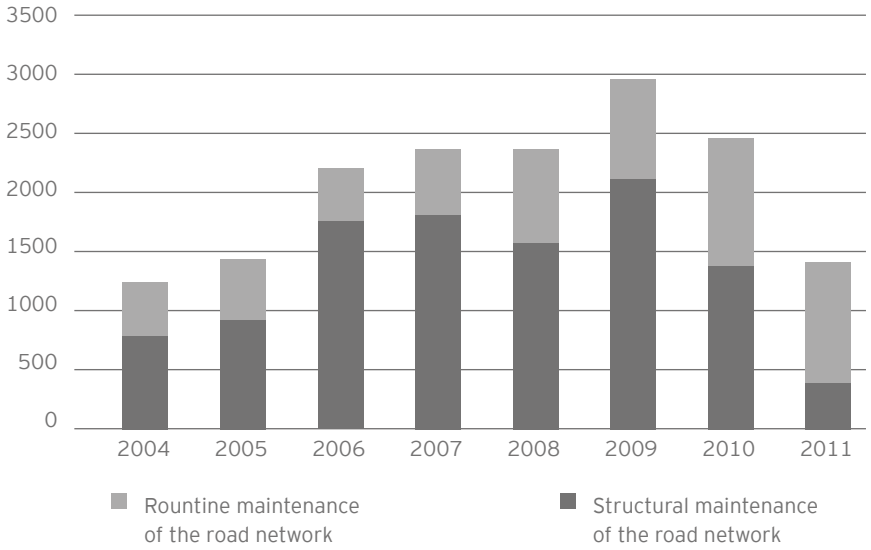


Source: own illustration.

The total expenditure on maintenance of the national road network increased from PLN 1.2 billion in 2004 to nearly PLN 3.0 billion in 2009. In 2010, as budgetary means earmarked for renewals and road upgrading had been cut, the total maintenance expenditure dropped by 18% in relation to 2009 (Figure 9). Taking into account the Producer Price Index (PPI), annual expenditure on maintenance increased by 85% in the years 2004-2010 at fixed prices. In 2011 structural maintenance expenditure fell significantly.

Expenses on the road network renewals in 2004-2011 at the average annual level of approx. PLN 1.3 billion were characterised by the lack of stability. One may think of a separation of expenses on roads upgrading and bridge reinforcements, which are financed from investment budget (i.e. capital spending) from the total expenses on national roads renewals. However, in practice such separation is not always possible. Therefore, for the purpose of the present analysis expenses on renewals and roads upgrading are treated as complementary.

Figure 9. GDDKiA expenditure on national roads maintenance (current prices, PLN million)



Source: based on GDDKiA data.

Expenditure vs. Maintenance Needs

With total annual needs of national roads maintenance in the years 2008-2010 at the level of PLN 3.7 billion, the actual expenses were approx. PLN 2.3 billion, i.e. about 70% of needs. The indicator of financing maintenance needs reached the highest value in 2009 (80%) and the lowest value in 2011 (40%).

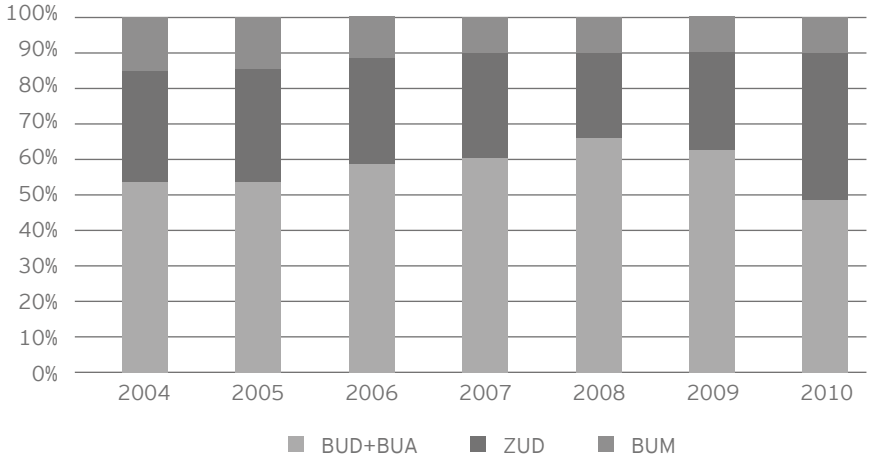
It was not possible to calculate the indicator of the financial plan implementation (costs planned to costs actually borne; performance to target indicator) as there is no year-to-year stability in financing the road maintenance.

In the period analysed the expenditure on BUSD (routine maintenance) increased from PLN 0.4 billion to PLN 1.1 billion (annual average of about PLN 726 million). On average, approx. 59% of this expenditures were expenses on routine road maintenance, about 10% on routine bridge maintenance and about 31% on winter road maintenance. The latter category of expenses is highly variable and depends on weather conditions in the winter period of a given year. In 2010 winter maintenance expenditure amounted nearly to PLN 0.5 billion and was by 86% higher than in 2009 and by 163% higher than in 2008.

Approximately 40% of expenses on BUD (maintenance of trunk roads) in 2010 was earmarked to pavement maintenance, primarily thermal repairs and bitumen plates; another 13% to maintenance of road aesthetics, and 10% to traffic signs and road surface markings. Comparing the structure of BUD expenses to that

in the preceding years was not possible due to annual changes in expense categorisation, to which data was collected in GDDKiA. Besides, the database is incomplete and contains erroneous data.

Figure 10. Structure of expenditure on national roads routine maintenance (%)

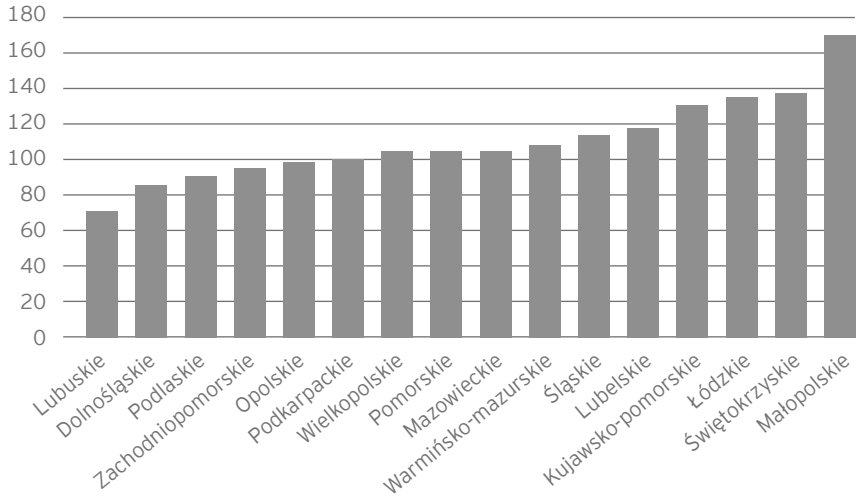


Source: based on GDDKiA data.

The analysis of unit costs of individual categories of works, carried out according to main cost items listed in the Catalogue of Maintenance Works in force in 2010, demonstrated high cost differences (even 8 times in the most extreme case) from division to division. It was however impossible to point out rational reasons for those cost discrepancies, such as for example the correlation between the model of maintenance management and the cost level of carried-out works.

Another indicator in this group is the average level of maintenance expenses per one kilometre of the road network managed by a particular GDDKiA division. In the years 2004-2010 this was PLN 110 thousand/km on average per annum. The highest values had been achieved in Małopolskie, Świętokrzyskie, Łódzkie and Kujawsko-Pomorskie; and the lowest – in: Lubuskie, Dolnośląskie, Podlaskie and Zachodnio-Pomorskie. Average maintenance expenses in Małopolskie (maximum value of the indicator) were more than twice higher than in Lubuskie (minimum value of the indicator), whereas the winter maintenance costs are the most decisive factor.

Figure 11. Average maintenance expenditure per 1 km of the road network in 2004-2010 in GDDKA divisions (thousands PLN/km)



Source: based on GDDKiA data.

3.3.2. Output Indicators

Output indicators inform about the number or scope of the maintenance works carried out. Based on GDDKiA Catalogue of Maintenance Works, Table 15 juxtaposes major types of works related to road routine maintenance and the value of indicators monitored in 2010. A precise definition of the output unit is difficult for some routine maintenance works. Square metre (m^2) or a linear kilometre of a road (carriageway) are most frequently used for comparative purposes.

Table 15. Selected output indicators for routine maintenance works

Catalogue division	BUD items	Output unit	Output in 2010
1. Road pavement	– thermal repair	thousand m^2	2,948.04
	– cold repair		25.66
	– repair with the use of asphalt emulsions and grit		192.70
	– bitumen plates		21,288.30
	– surface milling		235.85
2. Shoulders	– repairs and filling	thousand m^2	278.15
	– cutting and thinning raised verges		83,194.80

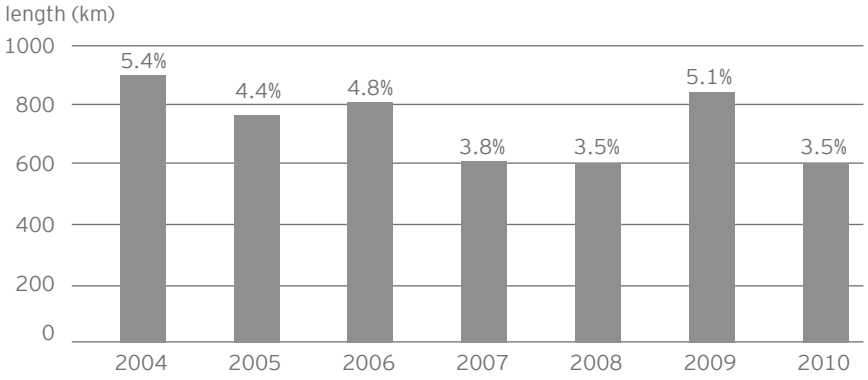
Source: based on the Catalogue of Maintenance Works and BUSD GDDKiA Monitoring Table.

Analogous output indicators are applied to routine maintenance of motorways.

Output Road Maintenance Indicators

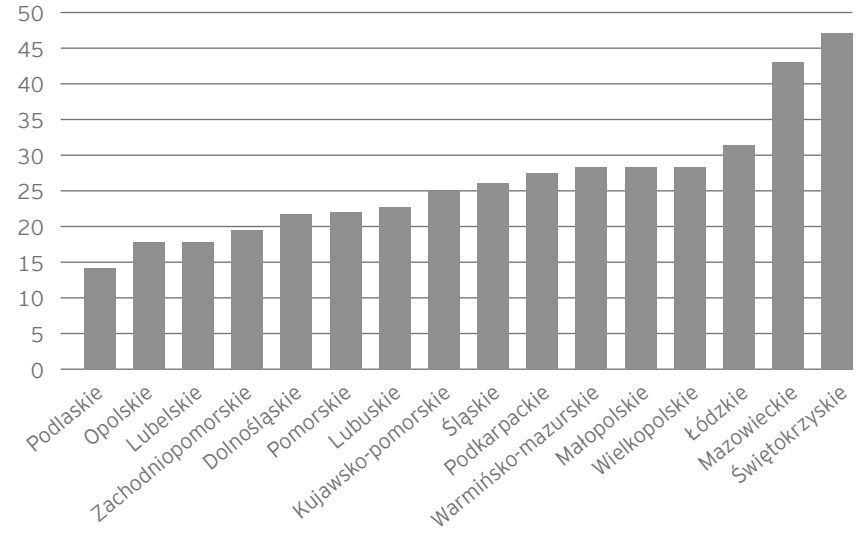
In the years 2004-2010 over 5.1 thousand kilometres of roads were repaved or upgraded (approx. 30% of the network). Annually, on average, approx. 735 km were repaved, i.e. 4% of the road network. The highest rate of road renewals, as per length, in the years 2004-2010 was achieved in Świętokrzyskie and Mazowieckie (above 40%).

Figure 12. Length and percentage share of repaved or upgraded sections of national roads in 2004-2010



Source: based on GDDKIA data.

Figure 13. Percentage share of roads renewals in 2004-2010 in the total length of national roads in voivodships (%)



Source: own based on GDDKIA data.

However, application of the indicator discussed above requires taking into account a number of additional indicators, which inform of the scope and complexity of works. Output indicators monitored by GDDKIA connected to road renewals are juxtaposed in table 16.

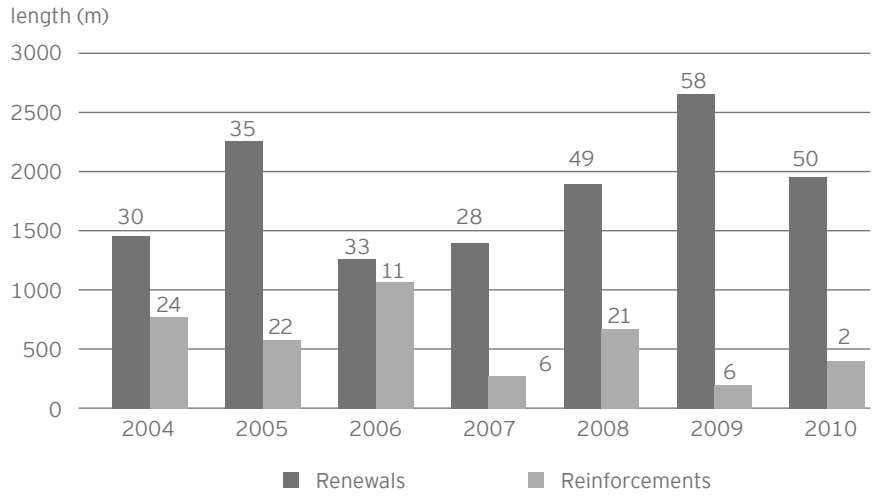
Table 16. Output indicators for road renewals

Indicator	Unit
– number of sections where works were carried out – number of commenced and completed tasks, including multi-annual tasks	–
– length of repaved sections of roads – length of upgraded sections of roads – length of drainage ditches subjected to renovation – length of sidewalk renewals	km
– number of completed tasks connected to improvement of traffic safety – number of intersections where traffic safety was improved – number of spots covered by traffic safety tasks	–
– total length of repaved roads – percentage share of the length of repaved roads in relation to the total length of the network	km %

Source: own based on GDDKiA data.

As far as the renewal of road structures is concerned the monitored indicators are: number and length of repaved and reinforced road structures (bridges, culverts) put into service in a given year. In the years 2004-2010, 283 structures of total length of 12.7 km (approx. 6.6% of the total number of bridges) had been renewed and 92 structures of total length of 3.9 km were reinforced (approx. 1.9%).

Figure 14. Number and length (m) of bridge structures repaved and reinforced in 2004-2010



Source: own based on GDDKiA data.

Calculation of the indicator of the material plan completion (performance to target) according to individual categories of works was not possible due to numerous corrections of the material and financial plan during the year in relation to the original assumptions resulting from changes in the level of budgetary funding.

3.3.3. Outcome Indicators

One of the key indicators of the effectiveness of road maintenance management is the condition of the road surface, which may be assessed on the basis of aggregate road surface condition indicators, upon data gathered in SOSN, SOSN-B and SOPO systems.

Road Surface Condition Indicators

Individual parameters of the road surface condition are obtained by means of automatic measurements and semi-automatic visual assessment, and they are referred to a four-grade classification (see table 17). The results are published every year in a report. The report for the year 2010 for the first time contains a comprehensive presentation of the technical condition of the national road network, i.e. it was extended by an analysis of the technical condition of shoulders and road drainage, the condition of which affects the pace of road surface deterioration.

Commencing from the second half of 2011, measurements of the technical condition of road surface will be carried out twice a year. The plan is to use radar techniques (penetrating radars) to recognise and continuously monitor changes to the construction of road surfaces, which will also facilitate gathering additional information about the road and its condition (transverse and longitudinal road evenness, coefficient of friction, bending).

Comparison of the change in the value of road surface condition index in a good, unsatisfactory and poor condition in the years 2004-2010 (Figure 15) shows that positive, notable effects of national road management in Poland were achieved. In the analysed period, the length of roads in good condition grew on average on the national scale from 45.5% to 59.1%, i.e. by 13.6 percentage points.

Nonetheless, over 40% of roads are in an unsatisfactory or poor condition, which means that they require repairs of various kinds. Nearly half of the repavement needs are of immediate nature, and the other half should be scheduled for completion in the short-term of several years. The condition of national road surface differs in individual voivodships (Figure 16), both in terms of total immediate needs, as well as in terms of individual operations carried out.

For instance, ruts occur mainly in the majority of central and eastern voivodships, and poor anti-skid properties are recorded particularly in southern and eastern voivodships and in Wielkopolskie (GDDKiA, Report on the Technical Condition of the National Road Network at the End of 2010).

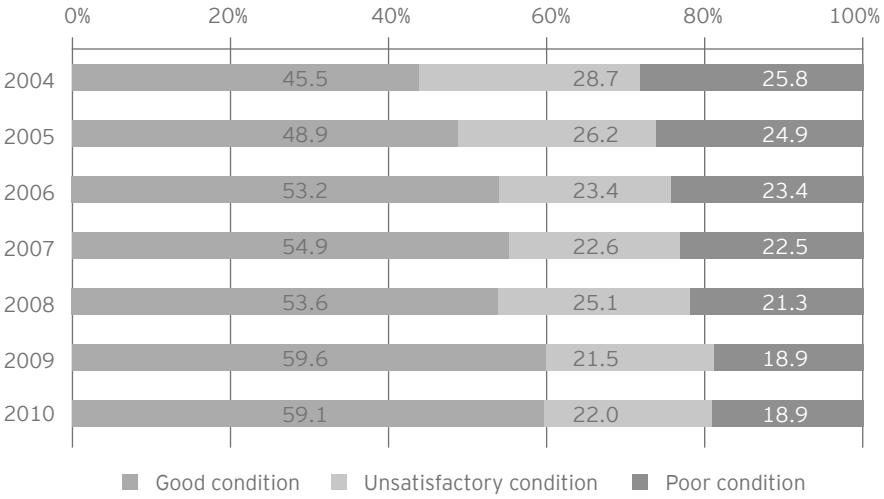
Table 17. Road surface condition indicators according to SOSN for repavement purposes

Road Category	Road Surface Condition	Outcome indicator	Total repavement needs
A category – good condition	New and repaved road surfaces which do not require repairs	Relationship of the network length in a good condition to the total length of network (%)	NO
B category – satisfactory condition			
C category – unsatisfactory condition	Damaged road surfaces requiring scheduled repavement	Relationship of the length of network in an unsatisfactory condition to the total length of network (%)	YES
D category – poor condition	Damaged road surfaces requiring immediate repavement	Relationship of the length of network in a poor condition to the total length of network (%) – indicator of immediate repavement needs	

Source: based on GDDKiA materials.

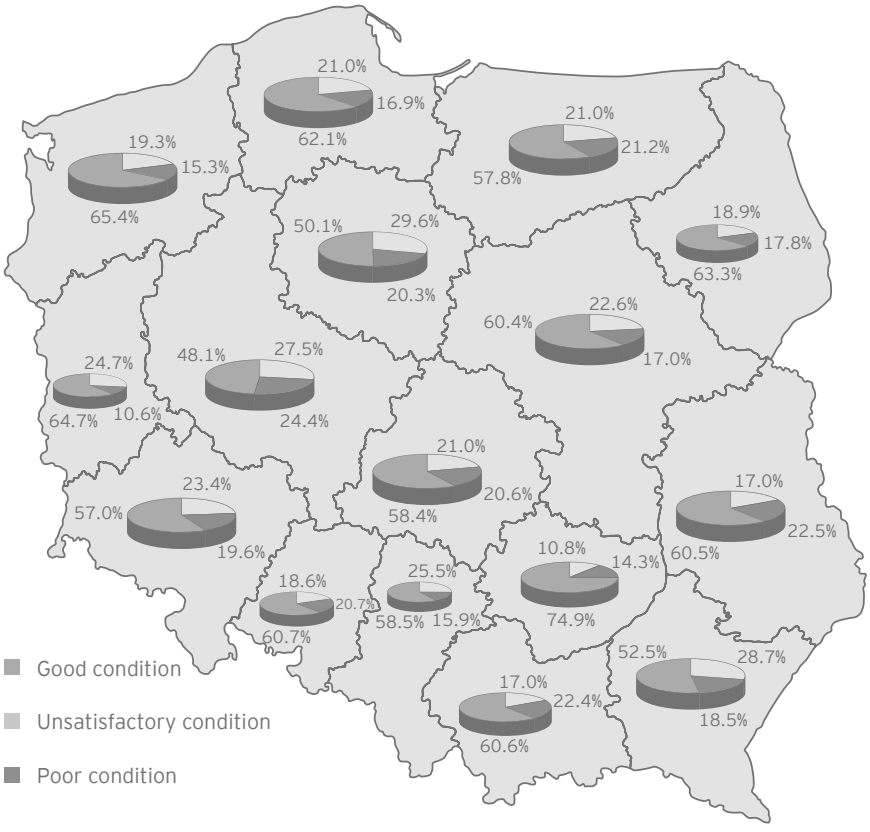
At the same time, a comparison of levels of average maintenance expenses per one kilometre of national roads and changes to the value of the road surface condition index for surfaces in a poor condition in individual voivodships points to a correlation between the expenses borne and effects achieved (Figure 17). The highest improvement of the road surface condition index for surfaces in a poor condition was achieved in voivodships, where the average annual level of maintenance expenses per one kilometre of road in the years 2004-2010 turned out to be over the national average (i.e. 110 thousand PLN/km): Świętokrzyskie, Małopolskie, Mazowieckie, Śląskie, Kujawsko-Pomorskie and Łódzkie. Lubuskie is an exception as at the end of 2010 it was characterised by the lowest percentage of roads in a poor condition in Poland (below 11%).

Figure 15. Surface condition of national roads in 2004-2010



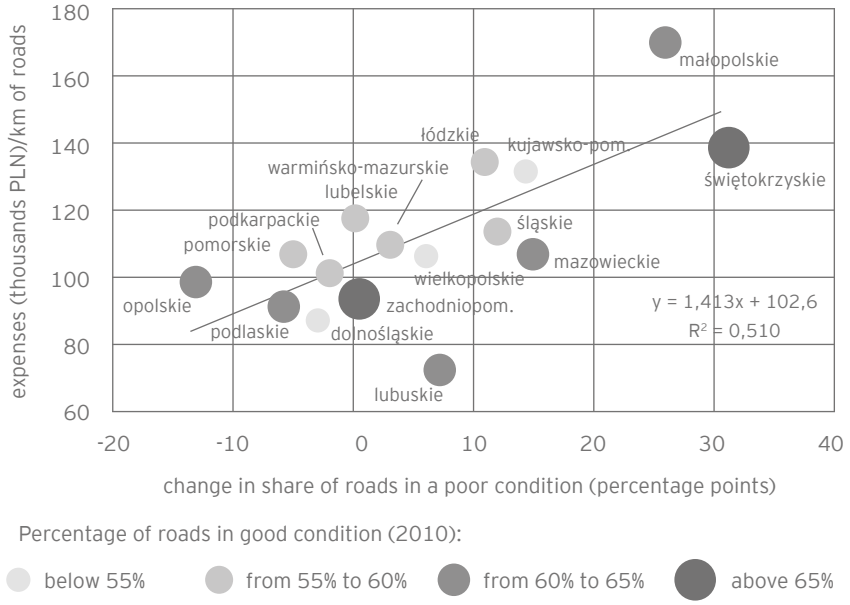
Source: based on GDDKiA reports on the technical condition of the national road network.

Figure 16. Surface condition of national roads in voivodships (2010)



Source: GDDKiA, Report on the Technical Condition of the National Road Network at the End of 2010, Warsaw, January 2011, p. 13.

Figure 17. Surface condition of national roads and the average level of maintenance expenditure in 2004-2010 in voivodships



Percentage of roads in good condition (2010):

below 55% | from 55% to 60% | from 60% to 65% | above 65%

Source: own.

According to GDDKiA estimates at the end of 2010, the total needs for repavement of the national road network that is the required funding to eliminate sections in poor or unsatisfactory condition on the entire road network, amounts to PLN 7.7 billion. What is more, the current expansion of the road network (by approx. 3.2 thousand km) will result in the necessity to increase maintenance expenses by about 7% in relation to the present needs (which should not be confused with the present level of financing). Nevertheless, under constraints of the state budget, the new Programme of National Road Construction (January 2011) earmarks approx. PLN 3 billion annually on average to maintenance of national roads in the years 2011-2013.

For the time being calculation of outcome indicators for road user service (quality of travel, traffic hindrances, response time) is not possible owing to the lack of relevant data.

4. National Road Maintenance Management in Selected Countries

4.1. National Road Networks and Financing Rules

In Europe, and EU member states in particular, road network management models differ from country to country both in terms of administrative division of roads and management structure, and as far as the rules for financing the road network development and maintenance are concerned. For example, federal roads in Austria are managed by a trading company, owned in 100% by the Federation and financed inter alia out of toll and vignette revenues. In England, it is a professional agency financed out of the state budget, and there is no special purpose road fund. In France, the road network of national significance comprising of tolled motorways is managed by a number of concessionaries responsible for constructing and operating motorways. Toll proceeds are the source of financing. Several years ago, the remaining road network of the national significance was shifted to the regional level and this way the management system for roads with national significance is fully decentralised. In Germany, a federal ministry is responsible for planning and financing the federal roads, however there is no federal road authority at the operating level – all road operations were transferred to road authorities in federal states. An extremely different case is the Finnish road network, which – except for private and municipal roads – is managed by a government agency responsible for the infrastructure of all transport modes.

Therefore, the basic criterion for the selection of countries for an international analysis – apart from maintenance practices essential from the point of view of this report – was the comparable structure of administrative division of roads and their management. The review covers six countries: Austria, Czech Republic, England, Germany, Italy and Switzerland. In all these countries the national road network is clearly separated from the entire road network of the country. There is no prevalence of the concession system and the present national roads authority operates for a sufficiently long time to assess the principles and management effectiveness. There are, however, differences among the selected countries as to quantity, density, and the standard of national roads (motorways and roads of lower standard), as well as at the level of economic development with all its consequences for the financial analysis. These differences

significantly affect cost levels, and hence their comparison, without a detailed analysis exceeding the framework of this report, might lead to erroneous conclusions. Therefore, the report concentrates on a comparison of maintenance management systems and points out the best practices on the international scale related to various maintenance aspects.

The following features of the road network are essential for the purpose of comparing national road networks in individual countries from the perspective of maintenance management, including maintenance financing:

- **length of national roads and percentage of motorways in that network** (or other roads with a similar standard), essential from the point of view of maintenance management as it determines the possibility to collect road user charges. For technical, political and social reasons only high-speed roads are suitable to charging. In addition, the more roads are built to a higher standard, the higher are the costs of repavement works. Part of national road network with a lower standard must be financed out of the general public budgets;
- **heavy vehicle transit**, which is the major determinant of accelerated technical wear of roads, therefore if no charges are collected for the use of national roads (toll or vignette) the foreign transit is financed by local taxpayers;
- **system of road charges**, which may be based on the central budget and proceeds from general taxes, direct or quasi-direct charges (tolls or vignettes) or by means of a mixed system.
  Direct charges are collected only on motorways and other roads with a similar standard (limited access roads, expressways). If part of national roads does not fulfil this standard and is not designed only for high-speed traffic between cities, such roads, by definition, must be financed out of general taxes or taxes on road transport.
  The "user pays" principle, which is promoted by transport economists and the EU on roads built to a high standard, assumes in theory that users are to cover the so-called short-term marginal costs understood as costs of operation and maintenance (costs of repavement per "each" user, spread over years). However, those charges do not have to cover the costs of the original investment, usually because the construction of infrastructure itself is treated as an obligation of the state. This rule should be abandoned only when motorways are built and operated by concessionaries.
  The international practice shows, however, that concessionaries rarely manage the task without any supplementary financial assistance of governments. In the European practice though, road user charges are earmarked (if) both for maintenance purposes, as well as investment purposes;

- **actual technical condition of roads and maintenance needs**. Roads and their individual technical elements have a specified lifespan. This is why in countries, which intensively built their road network (including motorways) at a fast pace, after a certain period of time huge maintenance needs arise abruptly in a short period of time. Maintenance needs are spreading more evenly over years in later periods along with diversified road traffic intensity.

In terms of so defined features of the national road network, there are significant differences even in the countries, which have similar road management systems. The basic information on the national road network in countries selected for the analysis is presented in table 18, whereas the most detailed statistical data is to be found in Appendix E.

Table 18. Characteristics of the road network in countries under review (2010)

Indicator	Austria	Czech Republic	England	Germany	Italy	Poland	Switzerland
Length of national roads (km)	2,175	6,989	7,185	52,700	24,600	18,608	1,766
Share of motorways in the national road network	72%	11%	42%	24%	4%*	5%	78%
Density of the national road network (km/100 km^2)	2.6	8,9	5,5	14,8	8,2	5,95	4,3
Density of the national road network (km/100 thousand inhabitants)	26	67	14	64	40	49	23
International heavy vehicle transit	yes	yes	no	yes	no	yes	partial
Road charges	yes	partial	no	partial	partial	partial	yes
Condition of roads	improving	backlogs	good	backlogs	backlogs	backlogs	very good

* The national road network does not include tolled concessed motorways.

Source: own.

Austria

National (federal) roads in Austria include mainly motorways and other limited access roads. The density of national road network is relatively low. Austrian national roads carry heavy vehicle transit, which increased after the end of transitional periods negotiated as Austria joined the European Community. (Initially Austria limited heavy vehicle traffic using the ECO-points system.) Thus Austria had a problem of accelerated road deterioration, which as a result of increased transit led to decreasing technical condition of motorways. On all federal roads charges are collected in the form of vignettes or tolls (GO-Box), or tolls are collected on special principles at selected sections of roads (tunnels and bridges). Federal roads are managed by ASFINAG, a company operating on commercial principles. Its main source of revenue is proceeds from tolls and vignettes, as well as proceeds from other activities (e.g. revenues of service areas). Contrary to other road authorities, ASFINAG pays corporate income tax. It is assumed that ASFINAG should have the capacity to finance the operations entirely from tolls and vignettes, as well as other commercial sources. The revenues should cover the costs of management, operating costs, as well as routine and structural maintenance, and moreover servicing of loans (mainly bonds) issued to finance larger investment projects. After a period of losses, and consequently governmental financial assistance, for several years (cf. Appendix E, table 3.4) its activity is profitable and provides the means to increase both the investment and maintenance activity. Financial planning is based on predictable revenues from tolls and vignettes, so planning maintenance works is possible in the long-term and it may include life-cycle pavement costing. Furthermore, since 2007, the company took over the entire maintenance activity from Austrian federal states and increased its standard also from road users' perspective (time of conducting works, signs, and hindrances on traffic lanes). In addition, an internal system for monitoring the effectiveness of operations was introduced, which includes measuring cost effectiveness of individual maintenance districts (internal benchmarking system based on an indicator analysis). In the recent years these activities contributed to improving the technical condition of the federal road network.

Czech Republic

The national road network in the Czech Republic is characterised by the highest density per 100 thousand inhabitants as compared to other countries analysed. Motorways constitute 10.5% of the length of the national road network. In the Czech Republic charges are collected for the use of motorways and some limited access roads and A-roads (vignettes for passenger cars and vehicles up to 12 tons, e-toll from heavier vehicles), yet the level of financial means, which is still too low leads to a backlog of maintenance works. However, in recent years financial means have been successively increased. A couple

years ago, the Czech superior inspection office claimed that one of the major maintenance problems was the price level of maintenance works which was too high for the Czech conditions. The remedy was a new professional system of cost reporting.

England

In England, motorways constitute 42% of the national road network, with a relatively low density of roads per 100 thousand inhabitants. Over a number of years much of the national road network was transferred (over 3,000 km) to lower levels of public administration (detrunking programme). The assumption of English transport policy so far is that no tolls are collected on motorways - they are entirely financed out of the central budget. There is also no earmarking of any public revenues from road transport to expenditure on road infrastructure. Allocation of funds is the result of budgetary negotiations. As a result of the financial and economic crisis of the recent years, the Highways Agency (HA) is currently preparing itself for the times of a tight budget policy with cuts in the agency itself and price modification in maintenance contracts. On the whole, the condition of English roads is good and to a large extent it results from professional management of the network based on compilation of technical and economic indicators.

Germany

The federal road network in Germany belongs to the largest in Europe and at the same time it is the densest one. Only 24% of that network is motorways. If the road category no longer corresponds to its function, it is declassified to the federal state level. All heavy vehicles on motorways (but not on the majority of the remaining federal roads) are subject to e-tolls (German Maut, which from 2005 replaced the vignette system), however not all revenues are earmarked for roads. The condition of roads is predominantly good or very good, however over the recent 10 years examinations of the road condition indicated backlogs in repavements in at least two reporting periods. For instance, in the reporting period of 2007/2008 over 40% of federal roads were found to be in a bad or very bad condition. Therefore, maintenance expenses increased abruptly.

Italy

In Italy, a number of motorway are operated by concessionaries (approx. 5,800 km), so they in fact are operated outside the system of national roads. Apart from concessed motorways national roads include both motorways (approx. 1,000 km, 3.9% of the non-concessed network of national roads), as well as lower standard national roads. The responsibility for the national roads management lies with ANAS, a trading company set up ten years ago. The company generates its own revenues, also from the construction activity outside Italy, as well as receives public subsidies. At the initial phase, till 2005, various

anomalies took place, which raised second thoughts of the public opinion and auditors. In addition, in Italy there is an officially recognised problem of negative influence of the mafia on road engineering. Therefore, since 2006 there are large-scale corrective measures being undertaken, among others the auditing and controlling are being reinforced. Similarly as in many other countries, there is a problem of insufficient financial means to maintain the national roads. There were attempts to increase funds for road maintenance, however unsuccesful (cf. Appendix G, table 6.4). In addition there is a problem with gathering maintenance data, especially in the area of routine maintenance[11]. The situation should improve after implementation of a professional software (SAP). To remedy the financial situation of national road engineering, new charges have been imposed in 2011 for the use of non-concessed motorways and limited-access roads (and there is a plan to expand the charging scheme).

In comparison to other countries, the national road network in Poland has an average density, and still the share of motorways in that network is too low. As it has been mentioned before, in Poland, alongside the administrative reform of 1999, part of former national road network was transferred to a lower level of public administration. During the last decade, when searching for effective and stable sources of financing the development of road network, there were attempts to use various forms of charges for the use of national roads and motorways in the form of direct tolls and lump-sum payments (vignettes). However, the sections of concessed motorways, where tolls are collected from all vehicles in Poland, should not be compared to concessed motorways in Italy, Spain or France, as concessions refer to short sections of motorways, which were only partly built by the concessionaries.

On Polish national roads the collection of e-tolls was launched from 1 July 2011 (viaTOLL system) for vehicles of gross vehicle mass (GVM) over 3.5 tons on motorways (excluding concessed sections), expressways and other national roads, which replaced the vignette system (annual vignettes were withdrawn from sale on 1 July 2010). In its first stage the system imposed fees on 1,560 km of roads, including approx. 579 km of motorways and 554 km of expressways, as well as 427 km of national roads with dual carriageways, and parallel roads under the charge of GDDKiA. Ultimately, up to 2014 the system will include approx. 4,400 km of roads (except concessed motorways). It is estimated that in the years 2011-2020 the viaTOLL system will

[11] Expenses in 2009 according to the Annual Report 2010 had been adjusted downward by 30% in comparison to the original data.

generate higher revenues than the vignette system used to. However, the financial means (received by KFD), will make it possible to cover only a small part of expenses necessary to expand national roads in Poland. Routine and structural maintenance is still financed out of budget funds (Part 39 of the state budget).

Switzerland

National roads in Switzerland are built to the highest standard, i.e. they comprise motorways and other limited access roads. From 2014 approx. 400 km of roads, which so far have been under the charge of cantons, will be added to the existing network. The density of the national road network is low. In Switzerland, owing to the fact that it does not belong to the EU it is possible to maintain strict regulations limiting the heavy vehicle traffic, which significantly slows down the technical deterioration of roads. On the other hand, Switzerland is a transit country in the long-distance transalpine traffic. Road management is the responsibility of a public institution (ASTRA), which is financed out of the road fund (Spezialfinanzierung Strassenverkehr, SFSV). The fund receives 50% of fuel tax proceeds, 100% of fuel surcharge proceeds and 100% of annual vignettes proceeds for the use of motorways (both passenger cars and trucks). The annual road budget is set by the parliament. Until recently proceeds were higher than annual needs. However, the surplus was not transferred for other purposes, but it was saved in the form of a road reserve. In 2011, as a consequence of an increase of road maintenance needs in the future (the road network of the Confederation will be extended in 2014) and following exhaustion of the reserve, actions were taken to increase proceeds from road engineering. There is a plan to increase the value of the annual vignette and to introduce a two-month vignette, which could be of interest to those car owners who rarely use motorways – up to now they were not interested in the purchase of an annual vignette and avoided motorways. However, rises will take place only after the road reserve drops below CHF 1 billion, which may occur in 2015. Moreover, Switzerland considers replacement of traditional vignettes with an e-vignette. Switzerland has the best maintained road network in Europe.

4.2. Review of the Road Maintenance Management Systems

An international review of national roads maintenance practises (apart from technical and financial factors) allows identifying some key factors decisive for the quality of maintenance management:

- **professionalization of road managements**, through replacement of a public office with a company or agency headed by professional executives. The legal form might contribute to separating the management process from politics as well as imposing higher standards for financial audit. Contracted executives are no longer public officers. Moreover, business experience is an obligatory criterion for those applying for an executive position;
- **existence of a coherent strategy of maintenance management, involving** either tight discipline in carrying out the maintenance works, or managerial approach that includes quantitative, financial and technical controlling;
- **treating road users as actual stakeholders in maintenance processes**. The condition of roads is not only an internal problem of the road authority, but vital primarily from the perspective of drivers and their passengers. A modern approach to maintenance practices can be seen in "road users' charters", application of control indicators from the road users' perspective (discussed in Chapter 2), as well as annual reports, which are made public. Surveys of road users' satisfaction are necessary, however in this context they usually focus on superficial issues.

Table 19. Determinants of road maintenance management effectiveness based on international comparisons

PROFESSIONALISM OF ROAD MANAGEMENT	COHERENT STRATEGY OF MAINTENANCE MANAGEMENT	USERS TREATED AS STAKEHOLDERS IN MAINTENANCE PROCESS
– low management effectiveness in the public sphere results often from politicising and lack of managerial experience by public officials – professionalism in the public sphere usually positively influences the quality of management processes	– road maintenance has financial, technical and managerial dimensions which should be coupled with each other – controlling technical parameters is of no significance, if it does not affect the allocation of financial means	– road infrastructure has a use value for road users, but not for the road authority, and the costs of maintenance works include "invisible" user costs as well – maintenance management should take into account the users' perspective

Source: own classification.

Tables 20-26 contain a systematised review of national roads authorities and principles of road maintenance in: Austria, Czech Republic, England, Germany, Italy, Poland and Switzerland.

Table 20. Management of national road maintenance in Austria

Road authority	**ASFINAG** – a trading company.
Category of roads	Federal roads (*Bundesstrassen*): federal motorways (*Bundesautobahnen*) and federal high-speed roads (*Bundesschnellstrassen*).
Model of maintenance management	Professional model based on the profit and loss account, and a complete control over the level of financial means at the disposal in a given budget year as user charges receipts are the company's revenues. As far as the management effectiveness is concerned – internal benchmarking system based on an indicator analysis.
Entities responsible for maintenance	Two subsidiaries ASFINAG Alpenstraβen GmbH (federal states of Tirol and Vorarlberg), ASFINAG Service GmbH (the remaining federal states; in 2010 all companies operating at the federal states level were merged into one company at the federal level).
Published maintenance standards and control indicators	Internal standards for carrying out works, including organisation of roadworks and availability of traffic lanes. Apart from restrictions concerning availability of the network, there are restrictions on traffic delays (up to 5 minutes) triggered by works. The plan till 2015 assumes, among others, a decrease in traffic hindrances by 15% in comparison to the result for the year 2010. For this purpose principles to assess road availability (*Verfügbarkeit*) had been elaborated.
Reporting	Detailed annual report, as well as yearly reports of rating agencies related to ASFINAG corporate bond issues.
Quality of maintenance	After a period of accelerated deterioration of road network due to an increase of heavy vehicle traffic, maintenance spending was increased resulting in a progressive improvement of the technical condition of the network; after ASFINAG took over maintenance works (2007), including structural maintenance, from federal states, an improvement can be seen as far as organisation of maintenance works is concerned*.

* According to Österreichischer Automobil-, Motorrad- und Touring Club (ÖAMTC).

Source: own research.

Table 21. Management of national road maintenance in the Czech Republic

Road authority	***Reditelstvísilnic a dálnic CR*** (Road and Motorway Directorate of the Czech Republic; RSD CR).
Category of roads	Motorways, expressways and A-roads.
Maintenance management model	Traditional, with a focus on internal analyses of maintenance effectiveness.
Entities responsible for maintenance	Mixed system of works carried out by own entities and contracted in a system similar to PBC. Maintenance of roads and expressways is the responsibility of 17 maintenance centres. There are also 2 separate entities that deal with planning. Maintenance of A-roads is the responsibility of 11 regional administrations.
Published maintenance standards and control indicators	Systematised IT system of collecting data on maintenance and its costs according to a strictly defined catalogue. It is not published. Lack of publicly defined and monitored outcome indicators from road users' perspective.
Reporting	Every 2 years, basic standard data and indicators in time series. From 2011 data on maintenance is published according to a revised catalogue of maintenance works.
Quality of maintenance	Insufficient, though it is subject to improvement. For many years backlogs were caused by a shortage of financial means and their ineffective use (as the Czech supreme control office intervened in this matter in 2002); at present of interest may be the system of price control related to maintenance works – apart from prices fixed in tenders, some prices are fixed by a central entity on the basis of reference data from regions (internal benchmarking).

Source: own research.

Table 22. Management of national road maintenance in England

Road authority	**The Highways Agency** – agency reporting to the Department for Transport, separated from the Ministry in 1994, responsible for motorway and trunk road management in England.
Category of roads	Motorways and other trunk roads; between 1998 and 2009 many road sections had been detrunked – transferred to local authorities (detrunking programme).
Model of maintenance management	Professional, based on predefined standards both related to entire maintenance management and individual maintenance contracts (outsourced to external companies; PBC); managing the value of infrastructural assets in place of quantitative management.
Entities responsible for maintenance	Structural maintenance – performance based contracts (PBC). Since 2011 there are new principles of contracting. Routine maintenance – in a mixed system (own and contracted). Other non-conventional methods, e.g. rehabilitate-operate contracts remunerated in the shadow toll system.
Published maintenance standards	Well defined and published; related to internal controlling on the basis of BVPI catalogue and performance to target indicators, as well as standards from road users' perspective defined in the Citizens' Charter and Road Users' Charter.
Reporting	Annual publication of business plans and management reports, including cost items and effectiveness indicators available for the general public; in addition detailed data is published by the Department for Transport.
Quality of maintenance	Maintenance of national roads is not considered to be a problem, if internal standards and maintenance control indicators are fulfilled. Maintenance works or strict monitoring of the road surface are required only for those road sections, which exceeded critical indicators.

Source: own research.

Table 23. Management of national road maintenance in Germany

Road authority	***Bundesministerium für Verkehr, Bau- und Wohnungswesen*** (Ministry for Transport, Construction and Housing) – formally only in the field of planning and financing. The Ministry has no subordinate federal authorities responsible for roads.
Category of roads	Long distance federal roads, including federal motorways and federal roads (*Bundesfernstrassen*, including *Bundesautobahnen* and *Bundesstrassen*).
Maintenance management model	Traditional.
Entities responsible for maintenance	Motorways and federal roads are built and managed by federal states at the request of the Federal Republic; all activities at the operational level, including maintenance, are taken over by individual federal states that is authorities which - as a general rule - are also responsible for state roads (*Landesstrassen*).
Published maintenance standards and control indicators	Internal standards, only a few of them are made public, however they are not subject to public scrutiny. Indicator analysis at an internal level, which to a large extent comes from the fact that the Ministry has no influence on management of works carried out by federal states. At present, the research and consulting unit *Bundesanstalt für Straßenwesen*, subordinate to the Ministry, carries out works on a complex system of maintenance management.
Reporting	Detailed report on road infrastructure investments (*Strassenbaubericht*) available from 1975; since 2008 it became part of the report on transport infrastructure investments (*Verkehrsinvestitionsbericht*), which contains information on infrastructure in all modes of transport. Until recently a detailed list of expenses was presented for all years in the same layout. At present, only general information is published about the expense plan and its execution. No reporting on the indicators of management effectiveness.
Quality of maintenance	Data on the condition of roads is made public with a 2-3 year delay; so far maintenance was considered to be sufficient, however in the recent years there were periods of insufficient maintenance and it is believed that without changes in management rules the condition of roads may deteriorate.

Source: own research.

Table 24. Management of national road maintenance in Italy

Road authority	**ANAS** – from 2003 a trading company.
Category of roads	National roads (strade di interesse nazionale) and motorways, however approx. 1,000 km of motorways are under direct management of ANAS, and approx. 5,800 km of concessed motorways are monitored by ANAS only.
Maintenance management model	Professional, based on a profit and loss account. Since 2006 there have been extensive corrective measures undertaken, with audit and controlling being reinforced. An internal benchmarking system is being created on the basis of an indicator analysis to manage maintenance works. A new system of asset performance indicators and operational performance indicators is being created.
Entities responsible for maintenance	16 regional offices and 4 motorway divisions.
Published maintenance standards and control indicators	There is a published Charter of Servicing Roads and Motorways (Carta dei Servizi Stradali e Autostradali), where minimum standards are defined together with the level of service which may be expected by road users (examples of indicators are to be found in Appendix G). Levels of service in many cases are not very high. However, there is no information to what extent those indicators are complied with.
Reporting	Comprehensive annual reports.
Quality of maintenance	Similarly as in other countries there is a problem of too low financial means for renewals and repavements. Tolls are imposed on more and more sections of roads; moreover quantitative objectives of maintenance were defined. ANAS introduced quality norms ISO 9001/2000 and SAP system related to maintenance.

Source: own research.

Table 25. Management of national road maintenance in Poland*

Road authority	**GDDKiA** Roads are owned by the State Treasury.
Category of roads	The national road network, including motorways and expressways (excluding sections of roads within the boundaries of 65 cities on county rights, including the capital city of Warsaw).
Maintenance management model	Traditional (mixed and outsourced). In 2010 for two newly built sections of an expressway PBC maintenance contracts were signed; further invitations to tenders have been published.
Entities responsible for maintenance	16 divisions, 105 districts with altogether 286 subunits.
Published maintenance standards and control indicators	Internal standards for conducting works. No indicators available for the general public, except for the Report on the Technical Condition of the National Road Network.
Reporting	Only on condition of roads, but not on maintenance.
Quality of maintenance	Insufficient, though it is gradually improving.

* Described in detail in Chapter 3.

Source: own research.

Table 26. Management of national road maintenance in Switzerland

Road authority	***ASTRA (fr. OFROU, it. L'USTRA)*** Public agency (*Bundesanstalt*). In 2008 it took over among others all responsibilities for national road maintenance from cantons.
Category of roads	National roads, i.e. motorways and other national roads (*Nationalstrassen, Autobahnen* and *Autostrassen*); there is a plan to add other (already existing) roads to the national road network.
Maintenance management model	Traditional.
Entities responsible for maintenance	5 regional branches.
Published maintenance standards and control indicators	Internal and external concerning the organisation of maintenance works, including bigger renewal works. For example, maintenance works may be carried out at sections of maximum 15 km length at minimum 30 km intervals. Key principles were imposed top-down by the Confederation (as an obligation to ensure effective traffic flows).
Reporting	A detailed annual report, additionally detailed statistics published by *Bundesamt für Statistik* or Ministry competent for road infrastructure.
Quality of maintenance	Very high; the national road network belongs to the best maintained in Europe; the technological norms for repavement are high – for example, the maintenance standards provide that works at the same section (resulting in its closure) may not be carried out more often than once in 15 years. At present there is a large-scale renewal scheme carried out to replace road surfaces older than 30 years.

Source: own research.

In most countries under review we can see the following tendencies:

- decreasing the size of the national road network by transferring part of national roads to lower levels of public administration. Germany is an exception here, however, at the operating level federal roads are administered by federal states, and in Switzerland where some additional cantonal roads are to be added to the national road network (the national road network is however relatively "small" in comparison to other countries);
- setting up companies, which apply management and control tools typical for trading companies, or other professionalization of road infrastructure authorities. Germany is an exception here, as there is no plan to set up a company or agency, however currently works are being conducted to improve the managerial toolkit;
- publishing annual reports of the road authority itself or reports related to national road engineering. From among countries discussed, only the Czech report has a form of an informational leaflet rather than an actual report. In the remaining countries, these are professional annual reports. In Germany a detailed "Report

on Road Investments" (Strassenbaubericht) has been published since the 70s of the former century;
- implementing indicators for road user service and making some or most of them public. From among countries under review systematised lists of indicators are published by road authorities in England and Italy; in Austria and Switzerland these are only single indicators;
- implementing IT systems supporting the collection and analysis of maintenance data. Such activities were undertaken in all analysed countries;
- paying even more attention to backlogs related to road maintenance and the problem of accelerated deterioration;
- introducing user charges not only on motorways, but also on other national roads built to a higher standard, according to EU recommendations. An exception in this field is still England (the question is for how long), however this results from general principles of economic and infrastructural policy.

Even so, one of the basic differences in maintenance management is the approach as to when and why renewal works are to be carried out. Excluding Switzerland where the necessity to carry out frequent renewal works was managed by limiting heavy vehicle transit and imposing restrictive technological norms, three approaches are noticeable:

- **English approach,** which is defining the asset performance indicator for road condition triggering repavement demand, monitored two years in advance. Further, it is the principle on stability of annual expenses on maintenance so that the minister of finance "is not taken by surprise" with increased financial needs of the road budget in various years;
- **German approach**, which is applying the principle of obligatory and facultative expenses, where maintenance expenses are considered to be obligatory, and only after satisfying maintenance demands, investment funds are allocated. If, for instance, huge neglect of maintenance is ascertained, such policy makes it possible to promptly carry out intensive maintenance works. For example, after a period when maintenance of federal roads did not constitute a problem, at the beginning of the last decade it turned out that only about half of surfaces on federal roads was in a good or very good condition. The alarming results of surface condition surveys for the years 2003-2004 and 2007-2008 triggered an abrupt increase of expenses on structural maintenance;
- **depending on availability of financial means**. This approach is applied in most countries analysed, but in Austria and Italy the funds for maintenance and other road objectives are (or are to be) strictly controlled by the authority. Along with simultaneous professionalization in management it is to result in a better condition of

roads. In Austria this effect is already visible, in Italy the system is only just being introduced. Contrary, in Czech Republic and Poland where road charging is not coherent, although the user charges are earmarked to the road budget, they are not coupled with the wear of roads. Furthermore, there is no strict correlation between the system of technical assessment of the road condition and the principles of allocating funds for maintenance.

Table 27. Determinants of road maintenance management effectiveness in selected countries

Country	PROFESSIONALISATION OF MANAGEMENT	COHERENT STRATEGY OF MAINTENANCE MANAGEMENT	USERS AS STAKEHOLDERS OF MAINTENANCE PROCESSES
Austria	yes	yes	yes
Czech Republic	no	no	no
England	yes	yes	yes
Germany	planned	partial	no
Italy	yes	under implementation	under implementation
Poland	no	no	no
Switzerland	yes	yes	no

Source: own classification.

In all countries analysed the professionalization of national road engineering and a coherent strategy of maintenance management (in any form) go hand in hand with a good condition of roads. This correlation is confirmed by the case of Germany where a short-term collapse occurred as regards the condition of federal roads. The condition of roads was improved, but one-off increases of maintenance expenses were necessary, and this experience resulted in commencing works on a new maintenance strategy. It is difficult to determine a correlation with treating road users as stakeholders of maintenance management, however in countries which do it, the condition of roads is better than in other countries. Nonetheless, it seems that the principle often repeated by the English Highways Agency is worth quoting in this context: road users are taxpayers, so they deserve "value for money".

4.3. Best Practices in Road Maintenance Management

The international review allowed to identify seven groups of best practices in road maintenance management that are described below.

I. Life-Cycle Pavement Costing

Traditionally, and usually due to budget constraints, repavement takes place on roads in the worst condition and where critical values of technical parameters are exceeded. However, from country to country there are differences in perception of the "critical value".

A relatively new approach to road maintenance is life-cycle pavement costing that involves repavement management carried so that the road surfaces are kept in a relatively good condition but simultaneously the long term repavement spending is the lowest possible. The issue is quite well described in the technical literature with reference to road sections. But, the life-cycle pavement costing at the level of the entire network is successfully carried out only by a few road authorities.

The IT-supported pavement management systems, which combine the technical and economic analysis are referred to as PMS systems. The forerunner in this field is FWHA, which over the recent twenty years successively introduced them in all US states. PMS in connection with life-cycle pavement costing, in the economic sphere is based on the assumption that maintenance projects should be carried out so that the maintenance costs are the lowest in the long run. To achieve such a target the analysis should focus on the scope of works and the moment/point of the pavement life-cycle. Maintenance projects are planned for the entire pavement life-cycle, and not only ad hoc at the moment as the maintenance needs appear. In addition, PMS make it possible to plan repavements in a way that facilitates annual budgeting, i.e. so that the demand for financial means is stable. It is based on the system of collecting and managing technical data for individual sections of roads (length, width, type of road surface, etc.), data on time and scope of carried-out works, data on the technical condition, as well as the volume and type of traffic. The analysis comprises of a technical analysis of a future pavement life-cycle, financial and economic analysis at the level of the entire managed network and for individual sections. In Poland the above-mentioned HDM-4 system fulfils the PMS standard.

The basic condition for introducing this type of pavement management system is predictability of the amount of financial funds which the road authority will be able to allocate for maintenance of the road network in the perspective of a few years.

A new technological solution related to road pavement management is the long-life pavement. As such pavements are more expensive than the traditional pavements, road authorities usually cannot afford to carry out all repavement works in a given year in this new technology. Amongst the countries reviewed a systematic solution in this field was introduced by the English Highways Agency. The HA defined an index indicating what portion of road sections repaved every year should be covered with a long-life pavement without dismantling the annual maintenance budget and at the same time without causing a backlog of maintenance works on the remaining network. A similar repavement scheme is carried out in Switzerland.

II. Road Surface Condition Indicators

In the United Kingdom maintenance planning relies on the road surface condition index, which was created for the purposes of British roads and is based on a set of technical indicators (ruts, evenness and road pavement roughness). It is assumed that keeping of the entire network in a very good technical condition is not justified, either technically or economically. A principle was adopted that repavement takes place only on the roads the condition of which exceeds the critical value of that indicator (100). On the basis of the technical data, the Highways Agency analyses, as well as makes public the information about the portion of network which exceeded the critical value of that index, and the critical values of the partial technical parameters. Thus, in contrast to other countries, there is no analysis of the technical condition of the network in terms of whether it is very good, good, bad, or critical because such definition is not synonymous to defining the moment of repavement needs (due to exogenous factors, e.g. transport volumes and loads). The planning of maintenance works and financial funds is based on the indicators of surface condition described in table 3.

As it follows from HA's management reports, the principle of renovating pavements which exceeded the critical value of the main indicator is obeyed. This does not mean that English roads are in a very good technical condition. Preventive measures are taken in order to not to exceed the technical condition which would mean accelerated surface deterioration. This way a predefined riding comfort is ensured for road users.

Riding Comfort Indicators

A similar policy is pursued by road authorities in Australia (Austroroads) and New Zealand (NZTA) where riding comfort indicators are applied. Such indicators are also based on technical parameters, with a definition of the technical parameter brackets, in the case of which road users should not experience riding discomfort. The measurement of the road condition index is the percentage of network ensuring riding comfort (i.e. above the critical value of the technical parameter index).

To sum up, differences in the policy of conducting repavements in each country – if such policy is actually pursued – usually lie in establishing the level of technical indicators which are considered to be critical or classify roads as requiring repavement works. The English road network does not have as high parameters as the Swiss one, however, in the opinion of HA it is well maintained because the predefined parameters of the target condition of road surface are complied with. However, the level of road maintenance in Switzerland is and will be unachievable in most countries. German standards are also higher than the English ones, but they are less and less often sustained. Yet, the said difference does not refer to countries with chronic backlogs in road renewals where roads in the worst condition are repaved insofar as financial means allow this. Of countries under review this concerns Poland, the Czech Republic and Italy.

III. Management of Maintenance Contracts

Performance Based Contracts (PBC)

Both routine maintenance, as well as repavement works are often outsourced to the private sector. A specific type of contracting are PBC contracts (used e.g. in the USA, Canada, Australia, England, and in the continental Europe they are applied with a very good effect e.g. in the Netherlands; first such contracts were also signed in Poland). The essence of a PBC contract lies in strictly defined principles of carrying out works, i.e. in what manner they should be conducted, under what circumstances and when. Road surface damage which qualifies surface for repairs or the height of grass requiring mowing are defined, as well as precisely – usually as to lead time duration in days or in some cases even hours from the occurrence of an event – the response time, that is the time during which a contracted company has to carry out a given task together with a margin of delay. The service provider receives the full contractual remuneration only if it carries out maintenance works in a manner and time defined in the contract. Each deviation leads to decreasing the remuneration. Contractual penalties are also strictly specified. Such contracts are widely described in the road engineering literature. In 2002 the World Bank published a template of the tender document for this kind of services together with general conditions.

This document is available free of charge online to be used by road authorities (World Bank 2002).

IV. Maintenance Standards from the Road Users' Perspective

Road authorities often introduce internal principles related to target technical condition of roads (pavement), as well as the way of conducting roadworks (time, hindrances on the network, information standards towards local communities etc.). However, until they are made public they constitute internal regulations which are or are not strictly obeyed. Nonetheless, road authorities undertake public obligations, i.e. they publish certain standards which apply internally. In some countries there is a tradition of publishing so-called Citizens' Charters, i.e. charters of citizens' rights to which they are entitled in return for taxes paid (the „value for money" mentioned above).

Road Users' Charters

On a similar basis some road authorities publish a document, which has already been mentioned above, entitled Road Users' Charter, i.e. a statement of road users' rights. A Road Users' Charter may be a document containing only general declaration. An example of such a declaration is the European Road Users' Charter published by the European Union Road Federation (ERF, 2005). For years, the English HA has published its road users' charter which includes much more detailed provisions, including precise indicators which then in subsequent years are publicly accounted for, i.e. information is published to what extent this indicator was complied with (cf. Appendix F). A similar charter was also drawn up in Italy (cf. Appendix G), however so far adherence to its provisions has not been publicly accounted for.

V. Minimising Traffic Hindrances when Carrying Out Roadworks

As far as users' rights are concerned, of importance are publicly declared and accounted for standards related to duration, time and distance between carried-out roadworks entailing a closure of the entire carriageway or traffic lanes. The objective of creating such standards and accounting for them is to make that road users – despite the necessity to conduct roadworks (not only repavements, but also modernisations) – experience the results of roadworks as rarely and as briefly as possible during one trip, which means that as rarely and as briefly as possible they are exposed to delays in travel time and consequently – in economic terms – additional costs of time lost in travel. Management of repavement works may mean accelerating them, carrying them out off-peak dates and hours and such organisation

of work that traffic hindrances are eliminated wherever it is only possible, including above all unnecessary hindrances on traffic lanes.

Duration of Roadworks

In terms of works duration the Japanese JRB introduced the strictest indicator, defining it as hours of roadworks duration, including occupation of traffic lanes (PI 3, hours of road work). Out of seventeen outcome indicators in road engineering, only two concern maintenance, with the latter referring to the value of roadworks. Thus we can say that in relation to management of maintenance works and other roadworks on the already existing road network, works duration was considered to be the most important element of maintenance management. This indicator was defined in hours per one kilometre of road in a year. In the long-term perspective the acceptable time of carrying out works will be systematically shortened. In 2002, when a new system of indicator assessment was introduced into road engineering, the roadworks duration indicator was 235 h/km (number of hours of all works in relation to the total length of network). In a five-year period till 2007 an objective was set to reduce that time by 20%. In each maintenance region local indicators were defined and in each region an objective was set to limit its value. In addition, a systematised management of the roadwork limitation calendar (or the on-street construction restriction calendar) was introduced by, first of all, marking in the calendar the dates on which no performance of works is allowed (i.e. dates on which traffic flow is intense also in connection with cultural and social events), along with a schedule for carrying out works so that they are finished within the prescribed time standards (Performance Management Office Road Bureau, Ministry of Land, Infrastructure and Transport 2004; JRB 2005).

Cost Benefit Analysis (CBA)

In the USA and Canada there are attempts to carry out the cost/benefit analysis (CBA) also for large-scale maintenance projects – repavements coupled with upgrading works on road sections which carry very intense traffic flows (Litman 2009). The project cash flow analysis on the cost side is supplemented with monetised costs of time (waste of time) borne by road users. Speeding up the works by means of, for example, increasing resources on site to shorten the scheduled time of roadworks results in rising maintenance costs – the scheduled budged must be higher. However, the costs of road users' loss of time decrease. The objective of CBA's analysis is to find such a variant of works completion which would lead to decreasing the total costs of those works (that is total costs of works performance and the costs of time lost by road users).

Standards for Roadworks Hindrances

Standards related to occupation of the road network due to works, including distances between road sections, on which works are carried out are nothing new and they are applicable – at least in theory – in many road directorates, also in GDDKiA (where, additionally, a Catalogue of Temporary Organisation of Road Traffic was prepared in 2011).

From among countries reviewed in this report, one may point out to the English HA, the Swiss national road authority, Astra, and the Austrian ASFINAG as examples of the best practices in this field. HA not only has in place road maintenance standards, but it also provides information in the annual report to what extent those standards have been met. The published information covers e.g. details as to what percentage of traffic lanes on the national road network was available for road users at peak hours (the standard is at least 98.5%), what percentage of major maintenance projects during a year fulfilled the standard of occupation with works defined as a maximum length of section of the carried-out works – 4 km distanced from one another by at least 10 km and what percentage of planned less complex maintenance works was carried out off-peak hours etc.

On the other hand, the Swiss Astra declares (and this is a standard established at the Confederation level) that the maximum length at the section of a motorway (78% of national roads in Switzerland are motorways) is 15 km. The minimum distance between sections where works are carried out is 30 km. However the strictest standard refers to the interval between works requiring closures of traffic lanes – and is set as no more than once in 15 years. Even if we remember that Swiss motorways are partially free from heavy vehicle transit (except for transalpine traffic), this signifies very high technological and qualitative standards of roadworks performance.

The Austrian ASFINAG declares that it will not carry out more than 3 worksites at a stretch of 100 km, and one section of works may not be longer than 10 km. A principle was also adopted that delays in travel time caused by roadworks should not exceed 5 minutes.

Assessment of Availability for Road Users

In mid-2010, ASFINAG created also a system for assessment of road availability for users (*Verfügbarkeit*). This system is based on three parameters. The first one is geometrical availability, i.e. ratio of the length of all traffic lanes available for users (that is not closed for traffic as a result of roadworks or during removal of road accident effects) to the total length of traffic lanes in the road network. The second parameter is speed availability based on the comparison of speeds available on the road network at a given time resulting

from traffic restrictions (for reasons specified below) in contrast to maximum permissible speeds. The third parameter goes beyond the worksite hindrances, and refers to traffic congestion (traffic jams). The road authority may actually limit also this kind of delays by means of the intelligent systems of traffic management (ITS). Data on road availability has been collected since the beginning of 2011. Hence, the first test results may be expected in 2012.

VI. Data Collection and Storage

Similarly as in commercial and service companies, the basis for management analytics carried out by a road authority should be complex data describing its activities. This concerns not only the data which serves reporting purposes, for instance – as in the case of road authorities – the data which must be collected and submitted to national statistic offices, but primarily the data facilitating management analytics.

The management of data itself has two critical points. First of all, data must be collected in an organised manner according to well-defined items: complete and not overlapping. Secondly, there is an issue of creating a database to store the original data (which is not processed for analytical purposes). The currently available IT tools facilitate (though they should also coerce) an automated manner of collecting data. The available software should be suitable to automatically inject data transferred from, for example, road authority local units to the main database in the head office. Original data should be stored in such a manner so that it is possible to develop time series at any configuration and from a single database.[12]

Among road authorities under review the best practices in this field include the database of routine maintenance created by the Czech national road authority, RSDCR. A direct cause behind creation of this base was the need to better control costs of national road maintenance (among other things after an intervention of the Czech control office). The database was divided into 9 groups sorted out according to maintenance activity, including not only types of maintenance tasks (8 groups), but also administration (the last 9th group). Each group was divided into subgroups and maintenance tasks (all marked with a digital code). For each task one completion unit was defined (kilometre of road/roadway, m^2, linear metre or linear kilometre, tons, items), whereas not only material completion is specified but also its costs. Collecting data is

[12] It is a precondition for multicriteria analysis of effectiveness in road authority local divisions (e.g. DEA).

based on so-called cost cards, which record not only the number of completed units of a given maintenance task, but also its direct costs broken down into material costs, remuneration costs and other direct costs paid. As it has already been mentioned, administrative costs are subject of a separate reporting group. The content of cost cards filled in at local divisions is automatically copied to the central database. The database makes it possible to develop time series of any data (in a monthly or annual layout) and to transfer it to a spread-sheet.

VII. Public Reporting

Reporting

All foreign road authorities under review and a great deal of other European authorities (though not all of them) present more or less detailed annual reports. By and large, the reporting obligation concerns only trading companies (e.g. Austrian ASFINAG, English HA, Italian ANAS or Portuguese Estradas de Portugal), which also publish standard financial statements.

However, among European countries the reporting on federal roads in Germany deserves special attention. An over one-hundred page report on road investments is submitted every year to Bundestag, and it is also made available to the public opinion. In the internet archives of Bundestag one may obtain access to a complete set of those reports beginning from 1975. In the years 1975-1997 this was a separate report under the title *Strassenbaubericht*. From 2008 it is part of a wider report entitled *Verkehrsinvestitionsbericht*. An appendix to the report describes all major road works completed in a given year. As far as maintenance expenses are concerned, data on both routine and structural maintenance is published together with expenses borne on maintenance services. A lot of information is to be found also in the descriptive section, although its weak point is the part relating to the condition of roads – it is quite brief and the data comes from two or three years ago.

5. Conclusions and Recommendations for Poland

5.1. Best International Practices

The review of foreign maintenance practices related to road maintenance shows some significant trends. First of all, road authorities put more and more attention to relations with the political-economic and social environment. As far as the interactions with the environment are concerned, we deal with two groups of stakeholders: legislative and executive authorities of the country, as well as road users and opinion setters, who speak for them in the media. The other focus in road maintenance are activities undertaken inside and for the purpose of the organisation of the road administration itself.

Figure 18. Stakeholders of the process of road maintenance management and interactions between them

Source: own illustration.

The basic problem in contacts between the legislative and executive authority lies in the manner of financing the road infrastructure, and thus the volume of financial means for road maintenance. It is difficult to speak of the best practices in this respect, because several solutions may be effective for a road authority. In England the road authority (HA) endeavours to manage renewal needs in such a manner that every year they absorb a comparable amount of financial means. On the other hand, the ministry of finance keeps its promise to allocate a stable level of funds every year. Another solution may be a strictly commercial one, which means ensuring that the road authority controls both the proceeds and expenditure on roads, for example it operates as an independent legal entity (ASFINAG in Austria). It is assumed that

the road authority will independently solve the "financial issue" as it is done in typical trading companies. In this context, special attention should be put to the German rule: "first funds for maintenance and then for investment projects". Because of this rule German federal roads are dominantly in good condition, However, a lesson should be taken as of the German experience from the past decade. The lack of a stable maintenance strategy led to an "abrupt" one-year demand for additional maintenance expenditure. In Germany, this was considered to be an essential problem and steps were taken to stabilise the maintenance strategy and this way to stabilise the level of maintenance investments.

Interactions Between the Road Authority and Road Users

The "interaction" of a road authority with road users may be twofold. First of all, road users are the "customers" of the road authority. An international analysis points out to two practices connected with this "customer" service. At the level of an internal analysis as to the effectiveness or efficiency within the road authority organisation, this means taking into account the perspective of road users through outcome indicators, that is indicators of quality of travel, traffic hindrances and response time. In addition, such indicators may be an element of the so-called road users' charter which is made public. It would seem that service indicators should have the highest values – however road authorities just as business entities in other industries weigh out between a declared "service level" and the borne cost. Thus the point is not to push up those indicators to unachievable levels, but to indicate a real minimum level which will be ensured (cf. ANAS). In this context we should also evoke the traffic hindrance indicators. The road authority should make efforts to decrease nuisances connected with roadworks. As the best practice in this field, we can consider the one applied by HA in England, where standards are not only made public, but meeting them is also accounted for in the HA annual report.

The other kind of interactions with road users, including the opinion-forming aspect, is the practice of publishing annual reports, presenting among other things the principles, actions and issues connected with road maintenance. One of the objectives of such a report is to present to the public opinion reliable data so that, for example, the discussion in the media, which reaches both decision makers outside the road authority, parliamentary opposition and road users, takes place at a higher level content wise than simple descriptions of drivers' every-day problems. A good example is Italy, where from the moment when the road authority began to publish annual reports, many experts, relying on them, publicly commented on funds "which disappear in the system" and which were intended for maintenance. In 2005 the ANAS annual report was consequently not approved, and

the corrective measures undertaken from that time have a measurable and visible effect.
Thus, as far as contacts with the environment are concerned, the best practices include:

- stabilising annual maintenance expenses at a similar level and undertaking a content-wise public discussion about the compulsory nature of maintenance expenses and the necessity to ensure the financial stabilisation related to maintenance;
- publishing professional annual reports;
- publishing a road users' charter, and – at the end of control periods – information about the level of fulfilling provisions of that charter.

System Approach to Road Maintenance Management

In order to achieve notable effects of carried-out current and structural maintenance works the road directorate should apply a system approach to the management of road maintenance inside its organisation, including among others:

- system of information management (collecting and storing data connected with the process of road maintenance);
- an IT system supporting management processes;
- system of assessment and monitoring the technical condition of road surfaces, elements of right-of-way and road structures;
- uniform procedures applied in all local divisions;
- uniform standards for road and bridge structure maintenance;
- guidelines and standards for performing and outsourcing maintenance works;
- principles for planning and programming maintenance works;
- mechanism of dividing funds among individual tasks and units;
- system of controlling and supervising the technical condition of roads and bridge structures, as well as the quality of works performed;
- system of management analytics based on a juxtaposition of effectiveness indicators;
- reporting and filing system;
- system of training employees at various levels of management.

Best Practices

As far as the internal activities within a road authority are concerned, the following best practices may be identified:

- catalogues of indicators in technical, managerial and economic dimension, which are applied and accounted for by road authorities for the purposes of analysing maintenance management effectiveness;
- professionalization of management; existence of a coherent strategy of maintenance management coupling the technical analysis with the economic analysis; treating road users as actual stakeholders of maintenance processes;

- in relation to conducting roadworks – application of time limits (duration of works or maximum time of delays caused by works), or limits of network occupation for the purpose of roadworks in order to limit the nuisance of maintenance operations for road users;
- in relation to information management – creation of a computerised system to collect and process maintenance data (technical, economic, road traffic and other data), with extended modules for management analytics facilitating generation of various reports;
- in relation to the best practices and effectiveness of road maintenance – creating internal benchmarking systems;
- in relation to the pavement management – PMS systems and successive replacement of road surfaces with long-life pavements. On the side of indicator analysis – defining the critical road surface condition, which triggers a renewal demand, in order to avoid the accelerated road deterioration and hence an increase in the maintenance costs in the future;
- in relation to outsourcing maintenance projects – PBC contracts.

5.2. Assessment of the Management System for National Road Maintenance in Poland

The present management system for national road maintenance in Poland is characterised by:

1) at the level of public finance and administration:

- a backlog in routine and structural maintenance of roads resulting mainly from not sufficient budgetary funding. This causes that a large portion of the network is in a bad and unsatisfactory technical condition, which decreases the security level of road traffic and increases the costs of vehicle maintenance. Further, the roadworks, which spread over many kilometres of roads and a long period of time, expose road users to loss of time and costs connected with it. It is not taken into account neither by decision makers granting funds for roads nor by GDDKiA to a sufficient degree;
- instability of GDDKiA's maintenance budget year to year, which makes it impossible to optimally plan maintenance works and causes a financial deficit of approx. PLN 1 billion, a gap which seemingly cannot be bridged for many years running. The excessively critical condition of roads, which were not repaved at the right time, accelerate their deterioration and increase over proportionally the renewal demands;
- instability of GDDKiA's maintenance budget during the financial year as a result of changes in the level of granted budget funds, which makes it impossible to rationally plan maintenance works and

calculate the completion degree indicators (performance to target indicators) of the material and financial plan according to individual categories of works;

2) at the level of GDDKiA's operations (cf. table 28):

- incomplete use of IT systems supporting maintenance management, including HDM-4 system, which has PMS functionalities facilitating combination of the technical and economic analysis. Results of technical analyses of the road surface condition do not transparently translate into needs in the financial dimension, which could serve as a "solid" basis during the annual budgetary negotiations;
- lacking system of comprehensive management analytics, including analyses of costs and prices of maintenance works as well as comparisons which would support implementation of the best maintenance practices;
- more and more attention is paid to the application of uniform standards and quality of performance of maintenance works so that proper care and well-selected materials could increase the pavement durability and prolong cycles between renewals;
- while data concerning the condition of road surface have been collected for many years, there is no central monitoring of the roadworks duration, occupation of traffic lanes in connection with conducted roadworks, and – as a result – there are no analyses in this field;
- lack of standards for limitation of traffic hindrances resulting from roadworks; however it must be pointed out that recently the Catalogue of temporary organisation of traffic was issued, which contains roadworks signage principles with the purpose to minimise traffic hindrances;
- lack of data, which would facilitate calculation of outcome indicators from the road users' perspective (i.e. quality of travel, traffic hindrances, response time);
- lack of a reporting system related to road engineering and management, i.e. an annual document with a permanent structure, which would include the most important information on activities undertaken by GDDKiA.

Table 28. Assessment of the management system for national road maintenance at GDDKiA

Features of the management system for road maintenance	Assessment of activities undertaken at GDDKiA	Desired state in line with the best international practices
Model of the maintenance system	Some progress made up to the current market conditions in the road services market, fostering life-cycle pavement costing, however the scale and pace of introducing maintenance contracts should be increased.	Long-term contracts based on the "Keep Up with the Standard" model (i.e. PBC).
Routine maintenance standards	Basic standards have been made uniform; insufficient progress related to minimising traffic hindrances when conducting roadworks, and public reporting and accounting for maintenance standards towards road users.	Uniform standards for routine maintenance, which facilitate monitoring of the road users' service based on output and outcome indicators.
System of data collection and storage	Considerable progress; further works required to implement and integrate applied IT tools.	Computer database, ERP/PMS software.
System of assessing pavement condition	Considerable progress; the system is being successively developed all the time.	System using modern technologies for automatic measurement and data registration, making it possible to comprehensively analyse the pavement condition and supporting the system of planning repavement works.
Budgeting system (for division of financial means)	Considerable progress, further works are necessary.	System based on real repavement needs, ensuring actual life-cycle pavement costing for the entire network.
Reporting system	Insufficient.	Detailed annual report in hardcopy and electronic form, which is made public.
System of monitoring the maintenance management effectiveness	Unsatisfactory.	System of monitored indicators taking into account experiences of other countries; internal benchmarking system.

Source: own illustration.

5.3. Recommendations for Road Maintenance Management in Poland

The following activities are recommended to increase the effectiveness in management of national road maintenance in Poland **in the short term:**

1) in relation to system of financing maintenance works:

- informing political and financial decision makers (Ministry of Finance, Ministry of Transport, Construction and Maritime Economy), as well as citizens about technical and economic management of road maintenance (especially that GDDKiA has and uses software, which makes such information possible), so that the issue of maintenance is treated on a par with the subject of constructing motorways and expressways;
- a precise description of the critical level of the road surface condition, as well as its monetisation (precise definition of the critical level of road condition and its monetisation following the example of HA), which would be the basis for obligatory treatment of needs related to repavement of road sections in a critical condition in the process of planning the state budget (following the example of Germany);
- causing the state to guarantee a steady level of funds and stable sources to finance maintenance;

2) in relation to GDDKiA's system of road maintenance management:

- improving the system of managing information and a wider use of IT systems to manage maintenance, including monitoring of expenses;
- clarifying and unifying maintenance standards on the entire national road network, which to a greater and greater extent would fit road users' needs, and they would also eliminate excessive losses of time caused by traffic hindrances; this may also refer to other road authorities in Poland;
- creation of a professional system to analyse the effectiveness of GDDKiA divisions' based on an indicator analysis and multi-criteria analysis (cf. Figure 6);
- creating a unit within the Road and Bridge Management Department to deal with comprehensive analytics of road maintenance management;
- accelerating the implementation pace of contracting works under the PBC procedure; detailed definition and checking qualifications of companies competing in tenders, and in the validity period of maintenance contracts: strict control of contractual performance and standards, and hence improving the PBC model used in Poland;

- annual publication of the report on road maintenance and investment, which would contain basic financial information and detailed information about carried-out projects, as well as achievement of short- and long- term objectives which would facilitate a higher level of public discussion content wise about roads and related issues.

The most important task to be faced in the coming years by GDDKiA, as well as other road authorities in Poland is to take into account road users' needs in operational activities.

Long-term Recommendations

On the other hand, **in the long term** it is recommended that:

- the duration of maintenance works should be measured on the national scale, as well as long-term objectives should be set to systematically decrease the duration of works (following the example of JRB) per one kilometre of national road network and to reduce delays in travel by road users (following the example of ASFINAG). Tough, pursuance of such an objective in the long run could lead to breaking the Polish "habit" of too long roadworks durations, in which road companies, as a result of being simultaneously obliged under many contracts, are often unable to ensure full staffing of the construction site in a continuous way;
- the list of monitored and calculated indicators should be expanded from the perspective of road users in accordance with practices adopted on the international scale;
- a road users charter should be prepared and published with a feasible level of maintenance indicators and objectives related to improvement of standards, including indicators connected to the duration of works, possibly delays in travel time, etc.

Appendix A.

Basic Definitions Related to Road Management in light of the Act on Public Roads

Road is a structure together with road civil engineering structures, facilities and installations, constituting a technical and utility whole, intended for road traffic flow, located within a right-of-way (Article 4 par. 2).

Right-of-way means a demarcated strip of land together with the space over and under its surface where a road is located along with civil structures and technical facilities connected with traffic flow, security and service, as well as facilities related to road management needs (Article 4 par. 1).

Carriageway means part of road intended for vehicular traffic (Article 4 par. 4).

Footway means part of road intended for pedestrian traffic (Article 4 par. 5).

Expressway means a road intended only for automotive vehicle traffic (Article 4 par. 10), which:

a) has one or two carriageways;
b) has grade separated interchanges with other roads for land and water transport, exceptionally allowing one-level intersecting;
c) has service areas for travellers, vehicles and freight, intended for road users only.

Motorway means a road intended only for automotive vehicle traffic (Article 4 par. 11):

a) has at least two one-way carriageways which are permanently divided;
b) has grade separated interchanges with all roads for land and water transport which traverse it;
c) has service areas for travellers, vehicles and freight, intended for motorway users only.

Road engineering structure means a bridge structure, tunnel, culvert, resistance structure (Article 4 par. 12).

Bridge structure means a structure intended for carrying a road, independent footpath or shared path for walking and cycling, wildlife crossings or other type of communication over a natural obstacle, especially: a bridge, viaduct, overpass, footbridge.

Public road means a road classified on the basis of the Act on Public Roads to one category of roads which may be used by everyone in accordance with its designation, with restrictions and exceptions defined in the Act or other special provisions (Article 1).

Public roads due to functions in the road network are divided into the following categories (Article 2):

1) national roads (drogi krajowe),
2) voivodship roads (drogi wojewódzkie),
3) county roads (drogi powiatowe),
4) municipal roads (drogi gminne).

National roads are owned by the State Treasury. Voivodship, county and municipal roads are owned by the relevant local government of the voivodship (Article 2a).

National roads include (Article 5 par. 1):

1) motorways and expressways, as well as roads lying on their route until motorways and expressways are built;
2) international roads;
3) roads constituting other connections ensuring cohesion of the national road network;
4) access roads to generally available border crossings serving pedestrian and freight traffic without any restrictions on the total weight of vehicles (combination vehicles) or exclusively freight traffic without any restrictions on the total weight of vehicles (vehicle sets);
5) roads which are alternative to toll motorways;
6) roads of major cities and metropolitan areas;
7) roads of military importance.

Road category means assigning to a road the relevant technical parameters resulting from its functional features (§ 3, par. 4 of the MTiGM Regulation on Technical Conditions Which Should Be Fulfilled by National Roads and Their Localisation). Roads in Poland are divided into the following categories (§ 4.1 of the Regulation):

1. motorways (marked with A symbol),
2. expressways (marked with S symbol),
3. major roads for high-speed traffic (marked with GP symbol),

4. major roads (marked with G symbol),
5. service roads (marked with Z symbol),
6. local roads (marked with L symbol),
7. access roads (marked with D symbol).

Roads classified as belonging to one of the categories, within the meaning of Law on public roads, should have the technical and utility parameters corresponding to the following categories of roads (Section 4.2 of the Regulation):

1) national roads – categories: A, S, GP, and exceptionally G category,
2) voivodship roads – categories: G, Z and exceptionally GP category,
3) county roads – categories: G, Z and exceptionally L category,
4) municipal roads – categories: L, D, and exceptionally Z category.

Types of works connected with alteration of the road present technical state (Article 4 par. 17-20):

- Road construction means the creation of a continuous right-of-way between specified places or localities, as well as its reconstruction and expansion;
- Road upgrading (modernization) means performance of works, as a result of which technical and operational parameters of the existing road are increased, without a need to change the boundaries of the right-of-way;
- Road renewal means performance of works reinstating the road to its original state, also with the use of building materials other than the ones used in the original state;
- Road maintenance means performance of preservation, cleaning and other works aiming at increasing safety and convenience of movement, including also snow removal and anti-skid measures in winter.

The General Director for National Roads and Motorways is the central authority of government administration competent for the affairs connected with national roads and responsible for (Article 18 par. 2):

1) performance of tasks of the national road administrator;
2) implementation of the state budget related to national roads.

The General Director for National Roads and Motorways is also responsible for (Article 18 par. 2):

1) participation in the implementation of transport policy related to roads;
1a) collecting data and preparing information on the public road network;

2) supervising the preparation of road infrastructure for the purposes of state defence;
3) issuance of permits for one-time ride of oversize vehicles at specified time and on a predefined route;
4) cooperation with road authorities of other countries and international organisations;
5) cooperation with local government authorities related to expansion and maintenance of road infrastructure;
6) traffic management on national roads;
6a) protection of road engineering monuments;
7) performance of tasks connected with preparation and coordination of construction and operation of toll motorways, or only operation of toll motorways (...);
8) collection of tolls in accordance with Law on Tolled Motorways and National Road Fund;
9) undertaking activities aiming at introduction of electronic systems of toll collection and a wide use of such systems, as well as cooperation in this field with other entities, in particular companies operating toll motorways;
10) performance of tasks resulting from the Act dated 12 January 2007 on Special Purpose Road Companies, and the agreement concluded under the procedure of Article 6 par. 1 of that Act.

Road authority means a government administration authority or local government units competent to deal with matters related to planning, construction, upgrading, renewal, maintenance and protection of roads (Article 19 par. 1).

The following entities are road authorities for (Article 19 par. 2):
1) national roads – General Director for National Roads and Motorways;
2) voivodship roads – voivodship executive board;
3) county roads – county executive board;
4) municipal roads – head of the municipal authority (town mayor or president).

The road authority is responsible in particular for (Article 20):
1) preparing drafts of road network development plans, as well as providing information on an ongoing basis about such plans to authorities competent to draw up local development plans;
2) preparing drafts of plans for financing construction, upgrading, renewal, maintenance and protection of roads and road engineering structures;
3) performing the function of an investor;

4) maintenance of road surface, footways, road engineering structures, traffic safety facilities and other facilities connected with a road;
5) performance of tasks related to traffic engineering;
6) preparation of road infrastructure for military purposes and performing other tasks in respect of country's defences;
7) coordination of works on the right-of-way;
8) granting permits for occupation of the right-of-way, as well as exits from roads and collection of tolls and fines;
9) keeping records of roads, bridge structures, tunnels, culverts and ferries, as well as making such records available at the request of authorised bodies;
9a) collecting information on national roads and passing it on to the General Director for National Roads and Motorways;
10) conducting periodical inspections of the condition of roads and road engineering structures, as well as ferry crossings, paying special attention to their influence on the condition of safety of road traffic;
11) performance of intervention, maintenance and security works;
12) preventing devastation of roads by their users;
13) counteracting unfavourable transformation of the environment which may arise or has arisen as a consequence of construction or maintenance of roads;
14) introduction of restrictions or closure of roads and road engineering structures to traffic, and setting up diversions through roads of various category, if there is direct threat to the safety of persons or property;
15) carrying out periodical road traffic census;
16) maintenance of roadside greenery, including the planting and removal of trees and shrubs;
17) purchase of real property for rights-of-way of public roads and disposal of them as part of entitlement to such properties;
18) purchase of real property other than the one mentioned in item 17 for the purposes of road management and disposal of them as part of entitlement to such property.

General Director for National Roads and Motorways performs its tasks with the assistance of the General Directorate for National Roads and Motorways. The General Directorate for National Roads and Motorways performs also the tasks of the national road authority (Article 18a par. 1).

Subject to par. 3a, the General Directorate for National Roads and Motorways consists of voivodship divisions (Article 18a par. 2). The area of a division operations overlaps with the area of a voivodship (Article 18a par. 3).

A minister competent for the affairs of transport, at the request of the General Director for National Roads and Motorways, by means of an order may set up regional divisions which will perform the tasks of the General Director for National Roads and Motorways related to individual motorways and expressways, where such divisions carry out activity in an area larger than one voivodship. The General Director for National Roads and Motorways appoints and dismisses directors of divisions of the General Directorate for National Roads and Motorways (Article 18a par. 3a).

Appendix B.

Glossary of Terms and English Abbreviations Used in the Report

API (*Asset Performance Indicators*) – technical indicators, which may also refer to life-cycle pavement costing and combine a technical and economic analysis.

BMS (*Bridge Management System*) – IT-supported system of managing maintenance and renewal of bridge structures (cf. PMS).

CBA (*Cost Benefit Analysis*) – cost/benefit analysis of investment projects (i.e. road engineering projects). Monetised external costs/ benefits are added to the analysis of actual cash flows, including for example the costs of road users' time.

Citizens' Charter – a charter of citizens' rights which are vested in them in return for taxes paid.

DEA (*Data Envelopment Analysis*) – multi-criteria effectiveness analysis of activity of operational units of the same organisation (so-called DMU – Decision Making Units). It facilitates a comparison of effectiveness without a need to attribute particular costs to particular activities – it compares the use of many resources (inputs) with work results defined in quantitative terms (outputs) based on the production function. It is used for effectiveness comparisons of the activity of operational units of the same public institution.

Input indicators – indicators referring to resources (e.g. fixed assets, materials, human resources).

ITF (*International Transport Forum*) – inter-governmental organisation (52 member countries), operating as part of OECD (formerly – before 2006 – ECMT).

KPI (*Key Performance Indicators*) – Key Performance Indicators (of effectiveness)

Long life (*life-cycle*) pavement costing – management of the road surface lifecycle.

NPV (*Net Present Value*) – current net value, i.e. the value of outlays to be made in the future, discounted to the present value.

OPI (*Operational Performance Indicators*) – (operational) indicators, which reflect the effectiveness of road maintenance management.

Outcome indicators – indicators of results, which correspond to indicators of customer service in commercial or service companies. In this case road users that means drivers and their passengers, are the customers. They should not be considered equivalent to indicators (barometers) of customer satisfaction based on surveys. They may be simple and complex indicators. Outcome indicators, which are usually made public, include, for instance, percentage of roads in a good condition in the entire road network, as well as accident figures.

Output indicators – performance indicators, which are simple (e.g. square metre (m^2) or linear metre /kilometre (linear metre/linear kilometre) of the repaved road surface) or complex ones referring to the volume/quantity of funds/resources used in the course of maintenance process (input/output indicators) (e.g. a simple indicator related to the number of employees). These are traditional indicators calculated by road authorities.

PBC (*Performance Based Contracts*) – maintenance contracts providing for strict standards of work performance – both in terms of technology and time (also related to response time when a maintenance need arises), the fulfilment of which is taken into account in settlements between the contracting party and the contractor. In Europe the road directorates in England, Netherlands and Finland have the widest experience in this field.

PMS (*Pavement Management System*) – IT-supported system of management of road repavements combining the technical and economic analysis. In the economic sphere it is based on the assumption that works should be carried out in such a manner that maintenance costs are the lowest in the entire road surface lifecycle. Its basis is the system of collecting and managing technical data for each road section (length, width, type of road surface, etc.), data on the time and scope of carried-out works, data on the technical condition, as well as the volume and type of transport activity. The analysis includes, among others, the technical analysis of further lifecycle of the road surface, financial and economic analysis at the level of the entire network under administration and in respect of individual sections. The American Federal Highways Administration has the widest experience related to such analyses.

Riding comfort (*smooth travel exposure*) – indicators to assess the comfort of travel, based on technical parameters, with a definition of the technical parameter brackets, in the case of which users should not feel a riding discomfort. The measurement of the indicator of the condition of road maintenance is the percentage of network ensuring the riding comfort (that means above the critical value of the technical parameters index).

Road maintenance effectiveness indicators – Road Maintenance Effectiveness Indicators.

Road surface condition index – an indicator of the road surface (pavement) condition, based on a set of technical indicators (ruts, evenness and roughness of road surface), applied by HA.

Road Users' Charter – a charter of road users' rights.

Routine maintenance – ongoing maintenance, a general definition used to describe a wide range of maintenance works like cleaning works on and about a road, including winter maintenance and minor repairs to the road surface.

Shadow toll – a toll paid to the licensee by the contracting party as an equivalent of the toll which would be paid directly by road users.

Structural maintenance – maintenance of the structure, a general term used to describe a catalogue of renewal works, the purpose of which is to reinstate the technical condition of the pavement to the original state.

Performance to target indicators – indicators of the completion vs. prior set targets, which refer both to cost planning and control, as well as other issues, e.g. the geographical scope of maintenance works (i.e. acceptable right-of-way-exclusions in connection with carried-out works) and the duration of such works (especially monitoring delays in the works schedule) for the entire network.

User satisfaction – in road engineering: the level of road users' satisfaction calculated usually as an indicator of satisfaction on the basis of road user surveys.

Appendix C.

Performance Indicators for the Road Sector (OECD)

Performance Indicators (PI) for the Road Sector

PI 1	Average road user cost (car and truck)
PI 2	Level of satisfaction regarding travel time, reliability and quality of road-user information
PI 3/4	Protected and unprotected road-user risk
PI 5	Environmental policy/programme
PI 6	Processes in place for market research and customer feedback
PI 7	Long-term programmes for construction, maintenance and operations
PI 8	Allocation of resources to road infrastructure
PI 9	Quality management audit programme
PI 10	Forecast values of road costs vs. actual costs
PI 11	Overhead percentage (administration costs)
PI 12	Value of assets
PI 13	Roughness
PI 14	State of road bridges
PI 15	Satisfaction with the road system

Source: OECD 2001b.

Appendix D.

Maintenance of National Roads in Poland (according to the data by GUS and GDDKiA)

Table 1. Basic data about voivodships and the national road network (2010)

Voivodship	GDDKiA Division	Area, km^2	Population	GDP, current prices*, million PLN	GDP per capita*, PLN	Length of national roads, km	Density of roads, km/100 km^2	Density of roads, km/100 thousand persons
Podlaskie	Białystok	20,187	1,188,329	30,903	25,951	977.3	4.84	82.24
Kujawsko-pomorskie	Bydgoszcz	17,972	2,069,543	61,721	29,834	1,066.6	5.93	51.54
Pomorskie	Gdańsk	18,310	2,240,319	76,243	34,267	921.6	5.03	41.14
Śląskie	Katowice	12,334	4,635,882	175,324	37,761	1,133.1	9.19	24.44
Świętokrzyskie	Kielce	11,710	1,266,014	34,747	27,333	755.8	6.45	59.70
Małopolskie	Kraków	15,183	3,310,094	99,509	30,220	1,019.1	6.71	30.79
Lubelskie	Lublin	25,122	2,151,895	51,082	23,651	1,058.2	4.21	49.18
Łódzkie	Łódź	18,219	2,534,357	81,869	32,162	1,348.8	7.40	53.22
Warmińsko-mazurskie	Olsztyn	24,173	1,427,241	37,076	25,970	1,327.2	5.49	92.99
Opolskie	Opole	9,412	1,028,585	29,680	28,761	778.9	8.28	75.73
Wielkopolskie	Poznań	29,827	3,419,426	127,361	37,424	1,730.8	5.80	50.62
Podkarpackie	Rzeszów	17,845	2,103,505	50,684	24,131	771.7	4.32	36.69
Zachodniopo-morskie	Szczecin	22,892	1,693,072	52,389	30,939	1,148.3	5.02	67.82
Mazowieckie	Warszawa	35,558	5,242,911	293,974	56,383	2,361.1	6.64	45.03
Dolnośląskie	Wrocław	19,947	2,877,840	110,448	38,395	1,394.7	6.99	48.46
Lubuskie	Zielona Góra	13,988	1,011,024	30,358	30,068	814.7	5.82	80.58
POLAND		312,679	38 200,037	1,343,366	35,210	18,607.0	5.95	48.71

* Data for the year of 2009.

Source: own based on Central Statistical Office data.

Table 2. AADT on the national road network in 2010 (vehicles daily)

Voivodship	GDDKiA division	International roads		Other national roads		National roads in total	
		AADT 2010	2010 /2005	AADT 2010	2010 /2005	AADT 2010	2010 /2005
Podlaskie	Białystok	10,169	1.12	5,690	1.26	6,702	1.22
Kujawsko-pomorskie	Bydgoszcz	12,866	1.06	8,522	1.34	9,725	1.22
Pomorskie	Gdańsk	18,539	1.22	6,966	1.45	10,436	1.31
Śląskie	Katowice	35,699	1.39	11,268	1.25	18,262	1.32
Świętokrzyskie	Kielce	12,259	1.31	7,088	1.28	8,357	1.29
Małopolskie	Kraków	20,536	1.25	9,427	1.25	12,953	1.25
Lubelskie	Lublin	10,028	1.20	6,205	1.32	7,459	1.26
Łódzkie	Łódź	18,820	1.20	7,327	1.15	11,471	1.18
Warmińsko-mazurskie	Olsztyn	13,573	1.13	4,615	1.17	5,684	1.16
Opolskie	Opole	26,513	1.49	6,350	1.22	8,684	1.30
Wielkopolskie	Poznań	16,835	1.22	9,013	1.15	10,918	1.18
Podkarpackie	Rzeszów	12,535	1.17	7,582	1.21	9,611	1.19
Zachodniopomorskie	Szczecin	10,932	1.16	5,044	1.13	6,892	1.15
Mazowieckie	Warszawa	20,006	1.10	7,067	1.27	10,906	1.17
Dolnośląskie	Wrocław	16,405	1.32	6,654	1.22	10,913	1.29
Lubuskie	Zielona Góra	12,734	1.15	5,328	1.16	8,283	1.15
POLAND		16,667	1.21	7,097	1.23	9,888	1.22

Source: General Traffic Census (GPR) 2010, Transprojekt-Warszawa.

Table 3. Expenditure on routine maintenance of roads and motorways (BUD+BUA, thousand PLN)

Voivodship	GDDKiA division	2004	2005	2006	2007	2008	2009	2010
Podlaskie	Białystok	8,882	8,045	8,576	15,516	21,813	23,392	22,135
Kujawsko-pomorskie	Bydgoszcz	13,012	16,401	11,251	17,380	26,339	31,728	23,650
Pomorskie	Gdańsk	10,741	8,183	11,124	15,748	20,877	25,757	23,827
Śląskie	Katowice	10,618	21,231	20,373	29,697	38,145	45,783	59,283
Świętokrzyskie	Kielce	9,159	9,918	9,574	12,533	20,318	21,351	18,613
Małopolskie	Kraków	13,648	14,676	13,632	22,879	40,939	35,767	36,747
Lubelskie	Lublin	9,950	15,396	14,656	15,596	23,750	27,526	26,305
Łódzkie	Łódź	20,852	7,381	34,176	39,021	50,133	48,179	48,213
Warmińsko-mazurskie	Olsztyn	15,670	15,937	22,174	17,343	27,599	28,500	22,824
Opolskie	Opole	16,837	16,075	19,479	19,948	30,167	29,299	36,621
Wielkopolskie	Poznań	17,486	24,502	20,379	32,448	50,048	51,768	42,100
Podkarpackie	Rzeszów	10,232	13,337	11,696	14,523	22,030	25,875	31,298
Zachodnio-pomorskie	Szczecin	12,904	11,926	6,476	15,583	22,512	20,238	39,118
Mazowieckie	Warszawa	25,962	33,822	28,094	40,406	62,854	62,535	40,197
Dolnośląskie	Wrocław	20,581	25,766	20,707	26,292	41,350	42,385	31,199
Lubuskie	Zielona Góra	11,214	11,429	11,591	14,994	20,522	26,102	19,312
Total		227,755	254,034	263,965	349,913	519,404	546,193	521,450

Source: based on GDDKiA data.

Table 4. Expenditure on winter road maintenance (ZUD, thousand PLN)

Voivodship	GDDKiA division	2004	2005	2006	2007	2008	2009	2010
Podlaskie	Białystok	6,040	4,336	6,555	7,512	6,401	9,439	13,939
Kujawsko-pomorskie	Bydgoszcz	5,681	6,364	6,902	7,596	5,662	6,885	22,143
Pomorskie	Gdańsk	5,339	7,794	5,170	6,637	7,730	11,202	21,949
Śląskie	Katowice	16,172	15,599	15,510	16,971	22,105	25,864	31,234
Świętokrzyskie	Kielce	5,351	9,681	6,797	8,289	7,164	10,313	21,262
Małopolskie	Kraków	10,324	5,374	17,749	15,805	22,130	22,900	30,000
Lubelskie	Lublin	8,836	8,907	5,017	8,915	8,854	13,277	24,918
Łódzkie	Łódź	8,261	4,642	8,147	12,606	13,204	18,260	24,483
Warmińsko-mazurskie	Olsztyn	9,416	12,980	6,823	12,247	10,004	14,535	27,052
Opolskie	Opole	5,522	7,896	7,684	8,011	6,761	11,343	19,626
Wielkopolskie	Poznań	10,143	10,681	14,050	11,289	10,401	18,200	45,500
Podkarpackie	Rzeszów	6,205	8,244	5,076	8,136	7,343	9,898	13,058
Zachodnio-pomorskie	Szczecin	9,526	13,442	9,275	10,379	9,462	14,545	31,353
Mazowieckie	Warszawa	17,115	21,191	18,909	22,118	20,942	34,632	77,497
Dolnośląskie	Wrocław	11,981	8,927	13,820	13,940	16,176	24,426	51,900
Lubuskie	Zielona Góra	4,704	6,890	2,794	5,918	6,783	9,768	20,236
Total		140,624	152,954	150,283	176,375	181,130	255,491	476,157

Source: as for table 3.

Table 5. Expenditure on routine maintenance of bridges (BUM, thousand PLN)

Voivodship	GDDKiA division	2004	2005	2006	2007	2008	2009	2010
Podlaskie	Białystok	1,023	1,429	1,824	2,073	2,504	1,992	2,385
Kujawsko-pomorskie	Bydgoszcz	4,462	3,798	3,310	3,592	4,009	4,010	3,817
Pomorskie	Gdańsk	2,914	3,300	3,095	3,712	3,962	4,540	5,961
Śląskie	Katowice	6,048	8,616	9,045	8,445	11,635	12,340	16,013
Świętokrzyskie	Kielce	2,786	3,474	2,326	2,423	2,627	3,758	2,191
Małopolskie	Kraków	5,915	6,631	6,951	7,180	11,418	12,263	14,679
Lubelskie	Lublin	2,780	4,450	3,068	2,988	3,283	3,991	4,310
Łódzkie	Łódź	3,389	3,714	2,286	2,944	4,835	5,800	8,236
Warmińsko-mazurskie	Olsztyn	1,845	1,662	1,613	1,724	2,201	1,819	3,872
Opolskie	Opole	3,474	3,254	3,302	3,516	4,700	4,699	3,291
Wielkopolskie	Poznań	2,316	2,218	2,657	3,356	4,712	5,500	3,630
Podkarpackie	Rzeszów	3,763	4,028	2,677	2,167	2,126	3,105	5,555
Zachodnio-pomorskie	Szczecin	2,450	2,468	2,395	1,044	5,393	4,500	6,315
Mazowieckie	Warszawa	7,230	7,476	6,903	6,451	7,115	7,200	7,527
Dolnośląskie	Wrocław	6,343	5,857	3,954	7,103	11,396	9,482	13,570
Lubuskie	Zielona Góra	2,526	2,433	2,853	2,612	2,162	2,022	2,002
Total		59,265	64,810	58,260	61,331	84,083	87,024	103,360

Source: as for table 3.

Table 6. Expenditure on routine maintenance of the network (BUSD, thousand PLN)

Voivodship	GDDKiA division	2004	2005	2006	2007	2008	2009	2010
Podlaskie	Białystok	15,945	13,811	16,955	25,101	30,719	34,823	38,460
Kujawsko-pomorskie	Bydgoszcz	23,155	26,564	21,463	28,568	36,010	42,623	49,611
Pomorskie	Gdańsk	18,995	19,278	19,390	26,097	32,570	41,499	51,739
Śląskie	Katowice	32,839	45,446	44,928	55,113	71,886	83,987	106,531
Świętokrzyskie	Kielce	17,297	23,073	18,697	23,246	30,110	35,423	42,067
Małopolskie	Kraków	29,887	26,681	38,332	45,864	74,488	70,931	81,426
Lubelskie	Lublin	21,567	28,754	22,741	27,499	35,888	44,795	55,534
Łódzkie	Łódź	32,503	15,737	44,610	54,571	68,173	72,239	80,932
Warmińsko-mazurskie	Olsztyn	26,932	30,580	30,611	31,315	39,806	44,855	53,750
Opolskie	Opole	25,833	27,226	30,465	31,475	41,629	45,343	59,539
Wielkopolskie	Poznań	29,945	37,401	37,086	47,094	65,162	75,468	91,230
Podkarpackie	Rzeszów	20,201	25,610	19,449	24,827	31,501	38,879	49,912
Zachodnio-pomorskie	Szczecin	24,880	27,837	18,147	27,007	37,367	39,283	76,787
Mazowieckie	Warszawa	50,308	62,490	53,907	68,975	90,912	104,368	125,222
Dolnośląskie	Wrocław	38,906	40,552	38,481	47,335	68,922	76,294	96,669
Lubuskie	Zielona Góra	18,444	20,753	17,240	23,524	29,468	37,893	41,551
Total		427,645	471,799	472,509	587,619	784,618	888,709	1,100,968

Source: as for table 3.

Table 7. Expenditure on roads and bridge structures (renewals and upgrading, thousand PLN)

Województwo	Oddział GDDKiA	2004	2005	2006	2007	2008	2009	2010
Podlaskie	Białystok	15,985	13,277	72,066	78,095	81,438	92,344	69,074
Kujawsko-pomorskie	Bydgoszcz	33,700	52,199	95,476	112,383	79,251	194,349	61,580
Pomorskie	Gdańsk	21,820	34,547	82,170	72,608	50,139	91,909	28,477
Śląskie	Katowice	32,603	45,634	115,524	80,581	67,307	146,365	40,826
Świętokrzyskie	Kielce	42,637	49,347	83,681	78,709	71,651	167,855	63,727
Małopolskie	Kraków	55,209	78,378	105,206	78,819	121,764	117,283	124,023
Lubelskie	Lublin	28,740	30,005	113,982	119,911	73,526	142,094	94,556
Łódzkie	Łódź	52,290	74,747	166,728	217,350	113,434	98,441	59,118
Warmińsko-mazurskie	Olsztyn	36,410	60,405	124,361	128,043	103,915	179,569	103,294
Opolskie	Opole	15,056	14,296	59,739	69,188	63,348	69,987	45,799
Wielkopolskie	Poznań	74,790	66,910	118,496	124,579	120,248	208,857	86,283
Podkarpackie	Rzeszów	13,625	22,139	38,194	67,371	74,030	51,777	37,703
Zachodnio-pomorskie	Szczecin	40,408	43,346	88,210	109,964	63,703	91,309	51,254
Mazowieckie	Warszawa	102,693	134,651	235,687	227,043	199,697	199,150	117,216
Dolnośląskie	Wrocław	24,741	30,936	68,767	87,732	34,486	66,371	142,780
Lubuskie	Zielona Góra	21,919	18,577	39,039	35,158	37,675	39,950	41,329
Roads in total		612,630	769,401	1,607,333	1,687,541	1,355,619	1,957,615	1,167,046
Renewals of bridge structures		59,300	64,800	58,300	61,300	83,900	87,000	103,100
Reinforcements of bridge structures		65,500	95,100	48,900	53,800	135,800	31,900	52,000
Bridges in total		124,800	159,900	107,200	115,100	219,700	118,900	155,100
GRAND TOTAL		737,430	929,301	1,714,533	1,802,641	1,,575319	2,076,515	1,322,146

Source: as for table 3.

Table 8. Indicator of immediate repavement needs (length of network in poor condition (D category) to the total length of network in voivodships)

Voivodship	GDDKiA division	2004	2005	2006	2007	2008	2009	2010
Podlaskie	Białystok	0.12	0.16	0.12	0.13	0.12	0.12	0.18
Kujawsko-pomorskie	Bydgoszcz	0.34	0.27	0.27	0.31	0.26	0.26	0.20
Pomorskie	Gdańsk	0.12	0.24	0.14	0.22	0.17	0.17	0.17
Śląskie	Katowice	0.28	0.29	0.23	0.23	0.21	0.21	0.16
Świętokrzyskie	Kielce	0.45	0.36	0.30	0.30	0.18	0.18	0.14
Małopolskie	Kraków	0.48	0.39	0.40	0.35	0.27	0.27	0.22
Lubelskie	Lublin	0.23	0.24	0.19	0.26	0.19	0.19	0.23
Łódzkie	Łódź	0.32	0.32	0.34	0.22	0.21	0.21	0.21
Warmińsko-mazurskie	Olsztyn	0.24	0.27	0.28	0.24	0.21	0.21	0.21
Opolskie	Opole	0.08	0.10	0.17	0.20	0.20	0.20	0.21
Wielkopolskie	Poznań	0.30	0.27	0.23	0.23	0.23	0.23	0.24
Podkarpackie	Rzeszów	0.17	0.22	0.27	0.25	0.17	0.17	0.19
Zachodnio-pomorskie	Szczecin	0.15	0.16	0.13	0.16	0.14	0.14	0.15
Mazowieckie	Warszawa	0.32	0.30	0.29	0.23	0.18	0.18	0.17
Dolnośląskie	Wrocław	0.17	0.16	0.12	0.19	0.14	0.14	0.20
Lubuskie	Zielona Góra	0.18	0.15	0.18	0.13	0.12	0.12	0.11
Average for the network		0.25	0.25	0.23	0.23	0.21	0.19	0.19

Source: Report on the technical condition of the national road network, GDDKiA, various yearbooks.

Appendix E.

National Road Maintenance in Selected European Countries

1. England

Table 1.1. GVA (Gross Value Added) per capita (current prices, GBP)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15,353	16,135	17,044	17,896	18,538	19,538	20,525	21,103	20,357	n/a

Table 1.2. Population (millions)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
49.45	49.65	49.87	50.11	50.47	50.76	51.09	51.47	51.81	n/a

Source: Office for National Statistics.

Table 1.3. Length of the national road network (which is the responsibility of HA, km)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
9,380	8,255	7,754	7,472	7,407	7,360	7,337	7,300	7,185	n/a

Table 1.4. Expenditure on national road maintenance (GBP millions)*

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Structural maintenance	489	445	492	409	476	565	542	511	504	733
Routine maintenance	301	320	326	371	312	354	371	406	422	574
Total	790	765	818	780	788	919	913	927	926	1,307

* The financial year ends on 31.03. Data until March of a given year.

Source: Department for Transport Statistics, various yearbooks.

2. Germany

Table 2.1. GDP per capita (current prices, EUR)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
25,500	25,900	26,000	26,600	27,000	28,100	29,500	30,100	29,000	30,300

Table 2.2. Population (in millions)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
82.26	82.44	82.54	82.53	82.50	82.44	82.31	82.22	82.00	81.80

Source: EUROSTAT.

Table 2.3. Length of federal road network (km)

Road category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Motor-ways	11,712	11,786	12,037	12,044	12,174	12,363	12,531	12,594	12,718	12,813
Federal roads	41,282	41,228	41,246	41,139	40,969	40,983	40,711	40,416	40,203	39,887
Total	52,994	53,014	53,283	53,183	53,143	53,346	53,242	53,010	52,921	52,700

Table 2.4. Expenditure on federal road maintenance (EUR millions)

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Structural maintenance	1,113	1,032	882	995	977	1,644	1,574	1,648	2,638	n/a
Routine maintenance	706	719	544	748	784	802	729	991	1,108	n/a
Total	1,819	1,751	1,426	1,743	1,761	2,446	2,303	2,639	3,746	n/a

Source: Strassenbaubericht, various yearbooks; Verkehrsinvestitionsbericht, various yearbooks.

3. Austria

Table 3.1. GDP per capita (current prices, EUR)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
26,600	27,300	27,700	28,700	29,800	31,300	33,000	33,900	32,900	34,100

Table 3.2. Population (in millions)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
8.02	8.06	8.10	8.14	8.20	8.25	8.28	8.32	8.35	8.37

Source: EUROSTAT.

Table 3.3. Length of the federal road network (for which ASFINAG is responsible, km)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1,999	1,966	2,005	2,034	2,035	2,062	2,104	2,104	2,135	2,175

Table 3.4. Financial results of national road authority – ASFINAG company (EUR millions)

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Revenues	966	1,097	1,243	1,874	1,900	1,991	1,975	2,011	2,036	2,472
Operational costs	719	891	1,130	1,562	1,324	1,435	792	1,155	1,217	1,640
EBIT	303	278	172	371	763	677	1,270	932	778	861
EBT	9	-17	-132	63	378	305	863	442	385	450
Loss/net profit	8	-17	-132	53	356	288	649	330	290	339

Table 3.5. Expenditure on federal road maintenance (EUR millions)

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Structural maintenance	130.9	161.5	246.6	306.8	284.3	331.0	319.0	303.0	336.0	363.0
Routine maintenance	120.2	132.0	141.0	151.0	159.0	164.0	167.0	164.0	n/a	n/a
Total	251.0	293.5	387.6	457.8	443.3	495.0	486.0	467.0	n/a	n/a

Source: ASFINAG Jahresbericht, various yearbooks; data of the Ministry responsible for transport.

4. Switzerland

Table 4.1. GDP per capita (current prices, CHF)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
59,100	59,100	59,100	60,600	61,800	64,900	68,400	70,700	68,700	70,700

Table 4.2. Population (millions)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
7.20	7.26	7.31	7.36	7.42	7.46	7.51	7.59	7.70	7.78

Source: EUROSTAT.

Table 4.3. Length of national road network (for which ASTRA is responsible, km)

Category of roads	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Motorways	1,304	1,303	1,351	1,340	1,358	1,360	1,382	1,382	1,406	1,406
National roads	368	402	408	393	397	397	380	382	383	384
Total	1,673	1,706	1,759	1,734	1,756	1,758	1,763	1,765	1,789	1,790

Table 4.4. Expenditure on national road maintenance according to ASTRA (CHF millions)

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Structural maintenance	457	488	517	534	580	612	549	507	549	bd
Routine maintenance	122	128	128	124	129	130	165	301	302	315
Total	579	616	645	658	709	742	714	808	851	n/a

Table 4.5. Expenditure on national road maintenance according to the Swiss Statistical Office (CHF millions)

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Structural maintenance	455	470	466	498	531	489	422	499	551	n/a
Routine maintenance	152	150	157	156	168	159	157	291	297	n/a
Total	607	620	623	654	699	648	579	790	848	n/a

5. Czech Republic

Table 5.1. GDP per capita (current prices, CZK)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
239,500	251,700	263,500	287,000	304,500	326,600	354,800	369,000	356,400	359,000

Table 5.2. Population (millions)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
10.27	10.21	10.20	10.21	10.22	10.25	10.29	10.38	10.47	10.50

Source: EUROSTAT.

Table 5.3. Length of the national road network (which is the responsibility of national authority, km)

Category of roads	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Motorways	517	518	518	546	564	633	657	691	729	734
Other national roads	6,091	6,102	6,121	6,156	6,154	6,174	6,191	6,210	6,198	6,255
Total	6,608	6,620	6,639	6,702	6,718	6,807	6,848	6,901	6,927	6,989

Source: ČSÚ – Czech Statistical Office.

Table 5.4. Maintenance budget (CZK millions)*

Indicator	2004	2005	2006	2007	2008	2009	2010
Maintenance of motorways	1,067	1,000	2,003	2,247	2,072	2,171	2,438
Maintenance of other national roads	4,511	3,318	5,646	7,124	6,762	7,987	9,190
Total	5,578	4,318	7,647	9,371	8,834	10,158	11,628

* Due to the new presentation layout of maintenance data from 2011, only available comparable data from 2004 is included to show routine maintenance and structural maintenance of the road surface.

Source: Roads and Motorways in the Czech Republic, Road and Motorway Directorate 2011.

6. Italy

Table 6.1. GDP per capita (current prices, EUR)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
22,000	22,800	23,300	24,000	24,500	25,300	26,200	26,300	25,400	25,700

Table 6.2. Population (millions)

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
56.96	56.99	57.32	57.88	58.46	58.75	59.13	59.62	60.04	60.34

Source: EUROSTAT.

Table 6.3. Length of the national road network (for which ANAS is responsible and concessed roads, km)

Road Category	2006	2007	2008	2009	2010
Motorways (*Autostrade in gestione diretta*)	905	905	905	905	905
National Roads (*StradeStatali*)	20,402	18,846	19,486	19,435	19,300
Other national roads	418	5,669	4,316	4,329	4,338
Total	21,725	25,420	24,707	24,669	24,543
Concessed motorways	5,658	5,695	5,695	5,727	5,778

Source: ANAS, Bilanzio di Eserzisio e Consolidato, 2007, 2008, 2009.

Table 6.4. Maintenance budget (EUR millions)

Indicator	2004-2006	2007	2008	2009	2010
Routine maintenance	No data*	688.0	805.7	645.8	543.8
Structural maintenance		271.7	847.69	964.0	598.5
Total		959.7	1,653.42	1,589.8	1,142.3

*Detailed data maintenance appear in the statements of the ANAS company only from 2007.
Source: ANAS, Bilanzio di Eserzisio e Consolidato, 2007, 2008, 2009.

Appendix F.

Road Users' Charter (The Highways Agency, England)

(declared in the settlement year of 2002/2003, obligations concerning maintenance)

(...)

Salt the road network ahead of the forecast formation of ice and snow. To be completed within three hours of the instruction to salt, in accordance with the Highways Agency Trunk Road Maintenance Manual Vol 2, Part 3.3.3

Indicator: The percentage of the trunk road salted within three hours of forecast formation of snow and ice.

Carry out regular inspections of motorways to search for and remove debris and litter, in accordance with the Environmental Protection Act 1990, as specified in the Agency's Trunk Road Maintenance Manual Vol 2, Part 1.12, and the DETR Code of Practice on Litter and Refuse. Debris constituting an immediate hazard will be removed or made safe immediately; litter will be removed on a variable timescale based on land use and traffic volume.

Indicator: The percentage of the motorway network where removal of debris and litter is carried out promptly.

Ensure that 60% of the core trunk road network, including all concrete sections, has a quieter noise surface by 2010. This target will be monitored and reported annually.

Indicator: The percentage of the core trunk road network, including all concrete stretches, that have a quieter surface by 2010.

(...)

Routine maintenance works carried out during the year will be undertaken off-peak in conformity with working time restrictions defined in contracts.

Indicator: The percentage of off-peak scheduled routine maintenance works carried out during the year.

Manage road works so that an average of 97% of traffic lanes on the network will be kept free of works during the year.

Indicator: The percentage of lane restrictions and closures at roadworks.

Plan and co-ordinate major road works so that a minimum of 90% during the year are no more than 2.5 miles long and are at least 6 miles apart.

Indicator: The percentage of major roadworks undertaken during the year that are no more than 2.5 miles long and at least 6 miles apart.

Re-open traffic lanes where completion dates have been advertised by the expected completion date in 90% of case.

Indicator: The percentage of roadworks re-opened on time where the expected completion date has been advertised.

Re-open traffic lanes on motorways and trunk roads closed by the police owing to accidents as soon as possible, and in any case not more than one hour after the Agent has received notification of release from the police, in 90% of incidents, during the year.

Indicator: The percentage of traffic lanes on motorways and trunk roads re-opened within one hour of receiving notification from the police following an accident.

Where it is likely that works may lead to delays of more than ten minutes, road users will be informed of this two weeks in advance of the planned start date, at the site. Information via the Agency's website and Information Line and to the local press and radio will include the advertised completion date and brief objectives of the scheme. Target = 95% of occasions during the year.

Indicator:The percentage of roadworks where anticipated delays of more than ten minutes are advertised two weeks in advance of planned start date.

(...)

At any major road works sites where lanes are coned off and there is a suspension of work for more than one day, a sign bearing a short explanation for this will be displayed. Target 95% of occasions.

Indicator: The percentage of major road works sites displaying an explanatory sign when lanes are coned off and work is suspended for more than one day.

Maintain road signs so that they are clear and visible, in accordance with the standards laid down in the Highways Agency's Trunk Road Maintenance Manual Vol. 2, Part 1.17.

Indicator: The percentage of trunk road signs that are clear and visible.

(...)

Załącznik G.

Minimum Service Standards according to the Charter of Road and Motorway Service (ANAS, Italy)

(the charter was applicable until July 2011)

Indicators for national roads

Scope	Indicator	Unit	Standard of service
Safety of travel	Inspections related to monitoring the creation of potholes in the road surface – frequency of inspections	figure/ month	2
	Removal of debris, remains, branches etc. lying on the road – % of cases of beginning intervention within 48 hours from notification	%	75
	Repair of potholes in the road within 48 hours from notification	%	80
	Repair of damaged barriers at sites with an increased risk – % cases of beginning intervention within 48 hours from notification	%	60
	Repair of traffic signs at sites with an increased risk – % of cases of beginning intervention within 48 hours from notification	%	70
	Undertaking activities to prevent ice formation – % cases of intervention consisting of salting the network 3 hours ahead of the forecast formation of ice	%	80
	Annual increase of improvements to surface drainage	%	20
	Mowing shoulders and embankments – frequency of mowing	figure/year	2
	Trimming greeneries – frequency of trimming	figure/year	1

Regularity of service	Snow removal – % of cases of beginning intervention within 60 minutes from notification in conditions of a sudden heavy snowfall	%	85
	Maintenance worksites – % of network, on which repavement works are carried out off-peak hours in the case of short-term works	%	80
	Reopening traffic stopped as a result of an accident – % of cases of beginning intervention within 3 hours from notification	%	90
User information	Variable message signs – installation of new variable message signs	figure	68
Customer service	Time of response to complaints and suggestions	days	2

Indicators for motorways

Scope	Indicator	Unit	Standard of service
Safety of travel	Removal of debris, remains, branches etc. lying on the road – % of cases of beginning intervention within 3 hours from notification	%	85
	Inspection of the road surface condition	figure/year	1
	Repair of damaged barriers at sites with an increased risk – % cases of beginning intervention within 24 hours from notification	%	85
	Repair of traffic signs at sites with an increased risk – % of cases of beginning intervention within 24 hours from notification	%	85
	Undertaking activities to prevent ice formation – % cases of intervention consisting of salting the network 3 hours ahead of the forecast formation of ice	%	90
	Annual increase of improvements to surface drainage	%	10
	Alarm facilities in working order – a percentage of facilities which are in working order in the total number of facilities installed	%	80
	Mowing shoulders and embankments – frequency of mowing	figure/year	2
	Trimming greeneries – frequency of trimming	figure/year	1

Regularity of service	Snow removal – % of cases of beginning intervention within 30 minutes from notification in conditions of a sudden heavy snowfall.	%	90
	Roadworks – % of network where the guaranteed distance between repavement worksites is at least 5 km	%	50
	Maintenance worksites – % of network, on which repavement works are carried out off-peak hours in the case of short-term works	%	70
	Reopening traffic stopped as a result of an accident – % of cases of beginning intervention within 1 hour from notification	%	95
Riding comfort	Service Areas – frequency of quality control	figure /month	1
Service for disabled travellers	Service areas – frequency of quality control	figure /month	1
	A percentage of service areas adjusted to the needs of disabled persons	%	80
User Information	Variable message signs – installation of new variable message signs	figure	28
Customer Service	Time of response to complaints and suggestions	days	2

Source: *Carta dei Servizi stradali e autostradali*, ANAS.

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