

Critical Factors of Sustainable Development in Road Management

Miroslav Němec^{1*}

¹*Management and maintenance of roads in the Pardubice region, Pardubice, Czech Republic;
Email: miroslav.nemec@suspk.cz*

***Corresponding Author:** Miroslav Němec

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Abstract: A focus on changing practices towards greater use of environmentally friendly practices in all activities related to the maintenance of the assets and buildings entrusted to the Road Administration and Maintenance logically entails increased financial requirements. As this is a relatively complex issue, road management must be understood in a holistic way, including risk assessment. The dynamics of the sector entails a considerable number of critical factors that have a direct or indirect impact on the achievement of the basic goals of infrastructure management and maintenance organization in the context of ensuring road management and mobility while respecting the basic concept of sustainability. The objective of this article is to define the critical factors of sustainable development in road management, especially in terms of ad hoc maintenance.

Keywords: Sustainable development, infrastructure maintenance, circular economy, crisis management, critical factors

1. Introduction

Sustainable development is a type of future development that seeks to reduce or eliminate the negative effects of the current development of society while preserving the current benefits so that current opportunities are preserved for future generations. [1]

It can be said that the success in implementing sustainable development depends largely on the collaboration and quality information from the institutions and individuals involved. However, these are just some of the problematic issues in the area of sustainable road management. Everything can be, and very often is, influenced by various interests and political and other considerations. [2]

The transport sector is undoubtedly one of the most important areas of sustainable development. Examples of sustainable transport have been addressed in many studies. The

most-widely used definitions of sustainable transport include environmentally sustainable transport, sustainable transport system, and process sustainability of the transport system. In order to achieve sustainable development, it is necessary to change the current consumption approach and replace current public policies in all their forms, whether legislative, strategic or economic, with a policy by cohesion policies, or future sustainability for all. Sustainable development goals concern all countries, and each of them can contribute to their achievement to some extent. [3]

The transport companies are also facing sustainability challenges as they strive to become more efficient in their economic management. There are several reasons that make it difficult for them to achieve this goal. [4]

Above all, the very definition of sustainable development is problematic, as it is not sufficiently elaborated not only in general but also in terms of the related scientific disciplines that should act as strategic goals to be pursued in a planned manner. Another problem is that economic development objectives are not sufficiently specified in terms of the complexity of the internal structure of the individual problems, i.e., with all the related factors that make them up, and thus do not allow for proper implementation aimed at their achievement. This is also related to the fact that the strategic definition of economic objectives is not linked to adequate management tools and methods that would allow them to be more easily implemented over time, specifically in the area of strategic management and the application of its tools. The Government of the Czech Republic is currently presenting a roadmap of what the economy should look like in 2030, i.e., with a view to the next 8 years, following the actions taken by EU Member States, as well as by representatives of individual countries around the world. The National Reform Program of the Czech Republic 2020, which contains measures aimed at restoring the long-term sustainable economic development of the Czech Republic, was approved at a meeting of the Czech Government in May 2020 and at that time already responded to measures related to the global COVID-19 pandemic. Although representatives of the Czech Parliament, regions, and municipalities, as well as other representatives from the economic and social spheres, participated in its preparation and the document reflects the annual key analytical documents issued by the EU, the basic shortcomings in the road sector and its sustainability are not sufficiently specified or addressed. [5]

Planning needs to be based on what is available, whilst in the future, measures need to be implemented to achieve sustainability in these areas, because it is essential for transport to be economic, and at the same time, the economy needs to use transport to continue to grow, because although transport is a very costly sector, it makes a significant contribution to public budgets through its performance, offering great scope for the sustainability measures implementation. [6]

Most documents on sustainability focus mainly on sustainability in building or creating new road structures, including infrastructure, with maximum use of renewable resources and minimum

impact on the environment. In the case of infrastructure, however, there should be greater emphasis on sustainable maintenance of existing infrastructure and more sustainable maintenance of existing assets. [7]

Potential changes adopted in this field will bring about an increase in funding in these areas, which is fundamentally at odds with the economic pillar of sustainability. If the focus of road administration and maintenance is on changing practices towards greater use of environmentally friendly practices in all activities related to the maintenance of the assets and buildings entrusted to it, this will logically entail an increase in financial requirements. Sustainable maintenance is more than just not wasting non-renewable resources. The cost-effectiveness of current practices needs to be addressed and possible changes proposed to reduce costs and, ultimately, the social impact of all activities undertaken. [8]

Sustainability in the management and maintenance of infrastructure has its own specificities that need to be implemented in sustainability documents, or the rules for meeting sustainability objectives need to be adapted to the conditions of a specific part of the national economy. If sustainability is to be implemented in the current sustainability model and sustainable maintenance is to be introduced, the future environmental impacts of activities leading to the extension of product lifetime need to be estimated. [9]

This approach is assumed to show that there are situations where maintenance is less sustainable than new construction or replacement of an existing feature than the less sustainable artificial extension of the life cycle of that feature under sustainable maintenance. It is therefore necessary to define and specify the basic maintenance criteria for sustainable infrastructure.

2. Sustainable Development in the Road Maintenance Sector

Road infrastructure is the basis for the smooth functioning of the economy in the area. It can be compared to a "bloodstream", the absence of which (absence of insufficient transport infrastructure services) will lead to the underdevelopment of the given area. Without a high-quality and operable infrastructure, it is not possible to ensure adequate service and mobility for citizens, which the EU sees as a right of every citizen. [10]

Ensuring continuous mobility within the road network at the required quality is a never-ending activity, as it is not a product with a finite life cycle, but an inherently cyclical or circular process of investment, management, management, maintenance, and repair. This also implies the necessity of continuity in ensuring the required extent of the road network in the required quality. Thus, it cannot be a "finite life cycle" concept, but an inherently "circular process" of management, maintenance, investment and governance. [11]

Any general concept has its pitfalls, and its implementation runs into the specifics of that particular field. The area of infrastructure management and maintenance at the regional level is no exception. In this regard, the Road Management and Maintenance organization is essentially a flagship of sustainability, as the very essence of its activity is maintenance and renewing, as well as extending the life cycle of infrastructure. [12]

As maintenance in the road sector is a cyclical process, a connection with the circular economy is perceived here as a tool of sustainable development. At present, however, in the Czech Republic, a rather "ad hoc" approach is generally used in the area of road administration and maintenance, which depends on the availability of financial resources that are insufficient/undervalued in the long term, since infrastructure degradation leads to a disproportionate growth in infrastructure as a result of an increase in mobility. Poor infrastructure maintenance due to long-term under-funding, leads to the fact that the state of the managed infrastructure can be characterized as unsatisfactory or in the state of emergency. It is therefore not possible to talk here about cyclical maintenance, and thus some kind of prevention of emergency situation, but about "ad hoc" maintenance based on short-term solutions to acute condition of roads that can be implemented within the framework of limited financial resources available to maintain the operability of the infrastructure. [13]

As this is a relatively complex issue, road management must be viewed comprehensively, including risk assessment. The dynamic nature of the field entails a considerable number of critical factors that have a direct or indirect impact on the achievement of the basic objectives of the infrastructure management organization and maintenance in the context of ensuring road management and mobility, while respecting the basic concept of sustainability. [14]

In the context of the above, and with regard to the philosophy of the circular economy, two basic concepts of infrastructure maintenance can be considered, namely ad hoc maintenance and cyclical maintenance. However, as mentioned above, the ad hoc approach is generally used in the Czech Republic at present. The ad hoc approach depends on the availability of financial resources, which are insufficient in the long term. From a longer-term perspective, this leads to a situation where not only is cyclical maintenance impossible, but also the ad hoc principle is not sustainable in the long term. [16]

If the societal goal is to have a quality infrastructure, it is necessary to deal methodologically with the way it is maintained, i.e., to choose a suitable approach and cope with the risks involved. There are undoubtedly many of these, which is why it is necessary to concentrate on 'risk management', to carry out a risk analysis, and to focus on the most serious risks.

It is not about the concept of risk within the functioning of the organization in which the actual system is implemented, but about the level of risk beyond the organization, where the external factors are also considered. Organizations engaged in the management and maintenance of Class II

and III roads are exposed to internal and external influences that create uncertainty in achieving the set objectives. The impact of this uncertainty can be described as risk. The need to manage risks is driven not only by the general requirements of proper performance in terms of corporate governance, but also by legal standards. [17]

One of the possible approaches is the so-called centralized risk management system. Its advantages lie in its high efficiency in risk management and in ensuring the stable operation and development of the organization, provided, of course, that the parameters are set correctly. The system can be implemented using the ISO 31000 (Risk Management) standard. Among other things, it recommends the implementation of risk management processes in the organization at the level of overall leadership, strategy, planning, management, processes, reporting, policies, values, and organizational culture. External factors are considered but cannot be directly addressed by the organization. [18]

At the same time, it is clear that a large number of activities related to risk management are also carried out informally as part of the day-to-day activities in various departments of the company, policies, and the organization itself. These activities are also an integral part of the management process.

In terms of the methodology, principles and practices, risk management is addressed, for example, in the already mentioned ISO 31000 or ISO 31010, or "A Risk Management Standard", which is discussed by the Institute of Risk Management, FERMA (Federation of European Risk Management Associations), and others. [19]

Risk management should be seen as a continuous activity within which the above steps need to be repeated and, in particular, deviations need to be monitored. It is important to focus on both positive and especially negative deviations. Deviations can occur both in the probability of the risk occurring and the level of impact. [20]

Much of the above material discusses risk from an operational, operational perspective, but when assessing the assurance of the organization's function, it is necessary to take a certain detached perspective and view risks as factors influencing the organization's strategy. [21]

For the purposes of this paper, risk will be considered as a source of risk that has the active property of negatively affecting the road transport sector. However, the principles of risk management are similar.

Thus, in terms of chronology (including the feedback loop), the following steps can be defined:

- Risk identification (i.e., identification of all significant sources of risk that could potentially affect the achievement of the objective or task);
- risk analysis (complex risk analysis; analysis of individual risks in terms of the probability of their occurrence);

- The sequences of these steps are based on the general principles of risk analysis but have been adapted to the specific needs of strategic road management. It is not simply the performance of an activity that is the responsibility of a state-funded organization, but a strategic view of the area. According to various methodologies, risk management consists of phases divided into 3 to 8 steps. However, some of them are intertwined and methodologically focused on the operational aspects of the organization's activities. [21]

The above breakdown has therefore been established. In fact, there are often situations in practice where duplication leads to confusion and repetition of information, creating problems of ambiguity.

Accordingly, a selection of significant risks has been made, with their evaluation and specification of the level of risk. The risk level is based on an assessment of the impact of the risk and the likelihood of its occurrence.

Risk Probability (RP)	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
Risk Impact (RI)						

A five-point risk impact (RI) scale is defined as follows: very low risk (1); low risk (2); medium risk (3); high risk (4); very high risk - critical (5).

The risk probability (RP) is defined on a five-point scale as follows: minimal risk (1); exceptional risk (2); common risk (3); probable risk (4); borderline risk (5).

The risk level (RL) is then expressed as the product of the risk impact and the probability of its occurrence. Thus: $RL = RI \times RP$.

The risk value is then divided into five levels: minimal risk ($RL < 5$); low risk ($5 \leq RL < 10$); moderate risk ($10 \leq RL < 15$); high risk ($15 \leq RL < 20$); extreme risk ($20 \leq RL$).

The graphical representation of the interdependence of risk impact (RI) and risk probability (RP) can then be illustrated by considering the risk value or risk level (RL), as the case may be, in the following figure. The level of risk is indicated under each heading.

Table 2 Ad hoc maintenance. Source: author

Risk - Name	Risk Owner	Risk Impact (RI)	Risk Probability (RP)	Risk Level (RL)	Note
Stability of allocated funds at the level of regions and municipalities	region	5	4	20	
Under-maintained infrastructure	region; administrative organization	5	5	25	Risk of further deferral of maintenance and associated increase in under-maintenance
Compliance with the expected scope and timetable of individual actions	administrative organization; contracting parties	4	4	16	
Occurrence of additional/supplemental work	administrative organization	3	3	9	Matter of selection of construction contractors
Errors in the planning of construction activities	administrative organization	4	4	16	In the case of ad hoc maintenance, the probability of risk is higher due to the requirement for higher operability
Cooperation between entities (authorities; institutions; other actors)	administrative organization; other entities	3	3	9	
Staffing of the organization's activities	administrative organization	3	3	9	
Implementation of winter maintenance according to legislative requirements and set plans	administrative organization	4	3	12	
Construction work prices (including materials)	market	4	3	12	
Energy prices (taxonomy implications)	EU	3	3	9	Change in concept of "clean" energy source; impacts on allowance prices; shorter planning time considered in ad hoc solution

As you can see in Table 2, the process defines the risks related to the approach to securing the road sector in the form of ad hoc maintenance.

In addition to the definition of risk, the entity under whose responsibility the risk falls is also identified.

From the whole range, the 10 most serious risks were defined and subsequently addressed.

The risks were defined using a brainstorming exercise involving a team of managers whose responsibilities include road management issues.

Risk map showing the number of risks can be seen below

Table 3 Measured values of sample. Source: author

Risk Probability (RP)	5					1
	4				2	1
	3			4	2	
	2					
	1					
		1	2	3	4	5
		Risk Impact (RI)				

As seen in Table 3, in the case of ad hoc maintenance, there are several risks identified as extreme. These are related to long-term underfunding in the area of infrastructure maintenance and management, the absence of cyclical maintenance and the application of the ad hoc principle to ensure the functionality of the infrastructure. This is the risk of further increasing the lack of infrastructure maintenance.

3. Discussion

The complexity of ad hoc road management is directly linked to the issue of financial resources. In the context of the above, there are many aspects to be considered, a large number of which are at the level of uncertainty. These include, for example, a 'correct' and above all realistic concept of defining the service life of a road structure, which can be and is influenced by traffic loads, vehicle axle loads and the resulting randomness of the occurrence of a defect in road passability. To illustrate this, the authors mention the situation during the construction of new motorway sections, where adjacent lower-class roads are extremely congested, degrading and requiring additional financial resources for reconstruction. The question is whether public resources can bear the costs of the destruction of roads due to construction loads in addition to the costs of building new

infrastructure. Practical experience shows that this is often a complex issue where the problem must ultimately be resolved at political level.

Similarly, the demands on public resources need to be seen in the same perspective, where, with the current tight budgets, there are efforts to eliminate mandatory expenditure and focus on extra-budgetary sources. Simply put, this refers to ensuring that costs do not weigh on the expenditure side of the budget. This is also linked to efforts to attract extra-budgetary resources. This can be done in various ways, by using extra-budgetary resources, alternative financing, PPP, and so on. However, it must always be borne in mind that ultimately the costs will be covered by public funds, which will be reflected in the relevant budget chapters, whether at national or municipal level. In view of this fact, it is thus clear that in many respects it is more a question of delaying the impact on public budgets. The recent situation shows that the interest rate is one of them. In the long term, the interest rate factor is a crucial parameter in managerial and financial decision-making on the implementation of the contract itself or the choice of financing method. This is, of course, also a consideration of the concept of the road management approach. It is also necessary to consider the time aspect, where infrastructure investments, even in terms of ensuring continuous maintenance and repair, are considered over a horizon of years or even decades. It always depends on the particular section, its parameters, load, etc.

4. Conclusion

Based on the above, the following conclusions can be drawn regarding the approach to asset management in the sector of road infrastructure management and maintenance. The goal was to define the critical factors for sustainable development, or a sustainable approach to asset management in the sector of road infrastructure management and maintenance, based on a search of available materials. As part of achieving the goal, risk mapping within ad hoc maintenance was carried out in order to show potential risks that can occur, identify the owner of these risks, and the level and probability of occurrence of individual risks. For an organization managing the infrastructure itself, this is an external factor that must also be considered in terms of risk. By its very nature, asset management in the road sector is a "circular" concept of asset management. However, it creates requirements for a predicted allocation of financial resources, which become mandatory from the perspective of budgets. The above risk analysis can be further used in the gradual implementation of individual steps within the framework of sustainable development. In the case of ad hoc maintenance, one risk was identified as extreme, specifically the long-term underfunding in the area of infrastructure maintenance and management, the absence of cyclical maintenance and the application of the ad hoc principle to ensure the operability of the infrastructure, which further increases the under-maintenance of the infrastructure.

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