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IDENTIFYING AND ASSESSING THE FUNCTIONALITY OF IT SYSTEMS FOR THE MAINTENANCE AND DEVELOPMENT OF THE ROAD NETWORK

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Abstract. The article presents the results of research aimed at identifying and assessing the functionality of IT systems in activities related to the maintenance and development of the road network managed by local government units. Starting the research, the authors were operating under the assumption that, nowadays, IT systems should play an important role in solving problems related to the management of road infrastructure. The applied research method took a form of a survey, and the research sample consisted of 100 local government units acting as administrators of the road network, i.e., administrators of municipal roads (AMR), county roads (ACR) and operating within cities with independent county rights (ACCR). The results of the research indicate that few administrators utilise integrated information systems in practice. Their users turned out to be mainly representatives of the ACCR group, who use several different support systems on a daily basis, with different functionality and usability. The operation of IT systems is mainly used at the level of operational

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work related to the implementation of ongoing maintenance activities, excluding the possibility of using them in strategic management.

Keywords: IT system, road infrastructure management, road maintenance solutions, strategic management.

Introduction

The research conducted by McKinsey & Company shows that in the near future technological trends, including the automation of road works and the digitization of roads (the so-called smart road), will significantly affect the effectiveness of road infrastructure management (Stern et al., 2021). According to the authors of this article, this impact will also be visible in the area related to the development of IT tools. In the current conditions, these tools should serve as the work environment for road administration bodies, especially road administrators, who struggle daily with the problems of rationalization and optimization of financial resources allocated for the implementation of statutory activities. Similar opinions are also expressed by other authors, i.a. Heller (2013), who is of the opinion that the effective use of management systems by the road administration is possible only with the use of appropriate software. Szarata & Turczynowicz (2021), in turn, draw attention to the fact that thanks to the digitization of the sphere of road asset management, local governments can achieve measurable benefits in the form of increased road safety and lower costs, and even the possibility of generating additional income.

The aim of the article is to identify and evaluate the functionality of IT tools dedicated to road infrastructure management on the example of road administrators representing local government units. When considering the management of road infrastructure elements, a wide range of meanings of this term was adopted, identical with the term "transportation asset management". It is defined as a structured set of actions taking place in a systematic and regular manner to maintain and improve the condition of road assets using economic and engineering analysis based on high quality information (Akofio-Sowah & Kennedy, 2014). Within the meaning of Art. 19 section 1of the Public Roads Act (Law Journal 1985, No. 14, item 60), the concept of a local government road administrator should be understood as an authority of a local government unit whose jurisdiction includes matters in the field of planning, construction, reconstruction, renovation, maintenance and road protection. According to Art. 19 section 3 and 5 of the said Act, depending on the road category, we are talking about county administrators, municipal administrators, and in the case of cities with county rights – mayors of cities acting as administrators.

The article was written as part of a research project "Optimization of road investments in the field of adapting the national road network to the traffic of heavy goods vehicles with an axle load of up to 11.5 tons" financed by the Gospostrateg (NCBR) programme. The main objective of the project was to develop, test, and prepare for implementation a tool to support decisions of road administrators in the field of optimal, long-term planning of periodic maintenance.

1. IT systems for road infrastructure management

Nowadays, it is difficult to discuss the issue of road infrastructure management without taking into account the role the integrated ERP (Enterprise Resource Planning) IT systems play in this process. A special role is given to the tools in the field of data analytics and information and communication technologies (ITC), without which making the right decisions in many cases turns out to be impossible or inefficient in terms of time and labour costs. It is obvious that activities related to the maintenance and development of the road network entail the need to solve many complex problems focused on finding the most advantageous variant of the planned intervention in accordance with the adopted assumptions (Mahmood et al., 2020; Dziadosz & Rejment, 2022; Zofka et al., 2014). These are often problems that require compromises to be worked out using multi-criteria decision-making analyses, related to i.a. the order of task execution, work scheduling, resource demand planning or creating road network models based on cadastral data. It should be mentioned that the management of road infrastructure, like any other economic activity, requires utilising the scarce resources, and their rational use determines the effectiveness and efficiency of supervision over road assets. Financial issues become a significant obstacle here. Road administrators, not having the necessary budget at their disposal, are often unable to ensure an adequate level of road safety (Łomecki, 2018). The above statement is confirmed by a large number of the interested parties themselves, who consider the lack of financial resources for the implementation of statutory tasks to be the main cause of their problems. It seems that in solving this problem – at least partially – IT systems may provide help. In many cases, they lead to a reduction in the cost of lost opportunities, i.e., those that could have previously occurred in a given organization due to the waste of resources used (Filipak & Panasiuk, 2008).

The literature on the subject reveals numerous benefits resulting from the implementation of integrated IT systems in management activities. Most often, they refer to the increase in work productivity in the form of time reduction, increase in the number of tasks performed, reduction of costs, as well as improvement of the efficiency of intra-organisational cooperation, mainly due to the improvement of information flow between individual units (Nwankpa, 2015; Anaya & Qutaishat, 2022; Trinoverly et al., 2018; AboAbdo et al., 2019). Taking into account their essence, five main groups of benefits resulting from the implementation of an IT system can be distinguished: (1) operational – due to the automation of cross-functional processes; (2) managerial – resulting from improved access to data and the possibility of their better processing, thanks to which managers can more efficiently manage processes taking place in the organization; (3) strategic – related to supporting business development, among others through more accurate decision-making and faster perception of the need for change; (4) IT – resulting from the reduction of the existing IT infrastructure management costs; (5) organizational benefits – these include faster learning process, as well as increased motivation and satisfaction of employees. Chopra et al. (2022), based on research conducted among 100 manufacturing companies, formulate the conclusion that in organisations that utilise IT systems work efficiency has increased by 63% on average.

IT systems dedicated to road infrastructure management, referred to as AMIS (Asset Management Information System), are a multi-module IT system that allows for comprehensive management of processes related to the care and supervision of both linear and point elements of road infrastructure throughout their life cycle. They integrate and automate the related processes, enabling their proper planning and coordination, while taking into account the rationalization of resource needs, thanks to which the efficiency and effectiveness of the undertaken actions increase (Wang & Pyle, 2019; Barth & Koch, 2019). They also provide important support in the circulation of documents related to road assets and allow for the processing of all their forms (Hastings, 2010).

Road infrastructure management also refers to pre-implementation tasks, which is why IT support related to the use of modern modelling methods and computer simulation in the design of road surfaces is equally important (Santosa & Ferreira, 2012). Research conducted by the California Department of Transportation shows that the solutions suggested by the IT system related to the place and time of carrying out maintenance procedures in many cases coincide with the indications of the most experienced road engineers (senior pavement engineers) (Mahmood et al., 2020).

IT solution providers currently offer a wide range of products dedicated to solving problems related to the functioning of road infrastructure managers. The specifications of some of these systems are briefly described below to give examples of usability of its tools. Furthermore, in the third part of this article, the software used by representatives of the Polish road infrastructure managers is described.

One of the most interesting proposals is the AMX (Asset Management eXpert) system, which consists of eight basic modules for managing road infrastructure assets that can function as independent applications or create an integrated IT system. In the analytical area, the solution provides a number of tools for reporting, monitoring and forecasting road incidents, life cycle planning, as well as management control using KPI indicators. The system also facilitates budgeting and cost control. The supplier has many implementations under his belt, including Norfolk County Council's Department of Transport, where the implementation of the system achieved operational compliance between the two departments responsible for managing projects and overseeing road assets (AME, 2021). Another example is the Comarch Ergo software, which consists of several tools supporting administrators in recording their assets and monitoring and maintaining the road network. The system collects detailed data on the condition of the infrastructure, which allows for the preparation of reports and thematic maps while taking into account the space-time variable. The software supports road administrators in the process of designing, building and maintaining road traffic organisation, as well as in the field of ongoing maintenance of road infrastructure. It allows recording and managing events related to construction work, as well as collecting detailed data on detected damage (Ergo, 2021).

An example of a solution supporting road infrastructure management

The RAM4PL system is one of the latest IT solutions supporting the management of road infrastructure in the area related to selecting the most optimal solutions in the field of adapting the construction of public road surfaces to the traffic of heavy vehicles. It is worth emphasising here that the costs of repairing roads damaged by trucks constitute a significant burden on road administration budgets, and a significant part of the linear infrastructure did not meet the technical parameters that would allow for safe transport with an axle load of 11.5 tonnes (Sivilevicius & Sukevicius, 2007). Studies show that freight operators as a major barrier to their development considered roads which were not designed for heavy vehicles (Świtała et al., 2020). To better illustrate the assessed problem, the results of heavy traffic loads on road surfaces can be cited, which show that the passage of one heavy truck is equivalent to 160 000 journeys made by one passenger car (Karkowski & Rafalski, 2013). Aarts & Feddes (2008) have pointed out that authorities have a tendency of thinking in terms of roads rather than vehicles when designing roads.

The discussed example is the result of many years of research and conceptual work on road asset management carried out on the basis of a self-assessment process proven in practice and discrepancy analysis, as well as taking into account the results of theoretical studies and expert work on renovation and investment decisions in the road sector. An important part of the research related to the implementation of the system was based on analytical and laboratory work related to the identification of the causes of damage to road surfaces, based on which 17 types of damages to asphalt surfaces and 12 type of damages to concrete surfaces were identified, along with the determination of potential causes of their formation.

The RAM4PL is a tailor-made system. In international practice, it is common to use methods for periodic planning of road network maintenance, which assume the first priority is to perform treatments on road sections with the lowest condition (the so-called reactive strategy, worst-first). The operation of the RAM4PL system is based on a proactive approach, and the selection of road assets requiring intervention is based on a multi-criteria analysis of the most beneficial solution. It takes into account both safety issues and the broadly understood minimization of necessary costs to be incurred.

Figure 1 shows the key elements of the RAM4PL system and the connections between them. The system has a classic three-tier architecture consisting of a data layer that is a data repository containing millions of data records; the logic layer, which includes all models, procedures and processes of the road asset management methodology, defining the method of data processing in accordance with the user's request, and the user layer used to generate and send commands and visualize the results obtained (Zofka, 2019). The

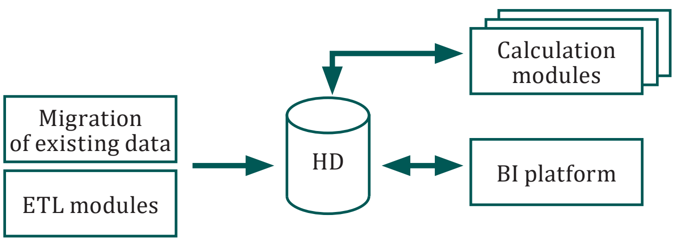

Figure 1. The general architecture of the RAM4PL system (Zofka, 2021)

tool uses a BI (Business Intelligence) analytical platform, and its central element is a data warehouse (HD) operating in PostgresSQL technology along with the GIS extension for storing spatial data. Self-management of data (including their preparation, processing and aggregation) is performed via ETL modules. In turn, their further analysis and optimization take place within the framework of the developed calculation modules that allow for the selection of only such maintenance scenarios that can be implemented in accordance with the current engineering knowledge and the adopted resource management strategy. The scenarios illustrate the forecast and theoretically possible variants of the technical condition of the surface structure, which are then subjected to technical and cost analysis. With the help of calculation modules, each tested road section is assigned possible scenarios, taking into account the expected level of services, i.e., safety, comfort, accessibility, resilience and expected travel time.

2. Materials and research methods

The research was of primary nature, and it was carried out in October 2022 with the use of purposeful sampling and an electronic questionnaire. The research sample consisted of 100 representatives of municipal road administration acting as road network administrators. It was solely made up of commune road administrators (AMR) located within the administrative borders of communes with a population of up to 20 000 inhabitants. The number of public road administrators within cities with county rights in the research sample was 21% (ACCR). The third largest group consisted of county road managers (ACR) (17%), who most often carried out tasks in county with a population of up to 50 000 people. The characteristics of the research sample in various cross-sections are shown in Figures 2–4. Representatives of the entities participating in the study were senior and middle-level managers, mainly men aged 36–45, with higher education. The respondents were most often employed in the rank of directors, managers, chiefs, inspectors and specialists.

Questions on the usefulness of IT and analytical tools and their practical application in the activities of road managers constituted a unified part of the questionnaire examining problems related to the management of road infrastructure elements by local government units. Opinion was measured with the use of two types of scales, i.e., nominal with the answers “yes”, “no”, “I don’t know” and seven-point, ordinal with ratings ranging from “definitely yes” to “definitely no” and “very bad” – “very good”. Most of the questions were closed, single or multiple choice. To measure number of difficulties linked to the managed road infrastructure, aggregating variables (ratio scale) were created based on the values of the nominal scales in a given area. In social studies, nominal scales only represent equality between elements of the same category, ordinal scales define the rank order between elements and ratio scales are a specific type of interval scale with the existence of a potential absolute zero value (Philippi, 2021).

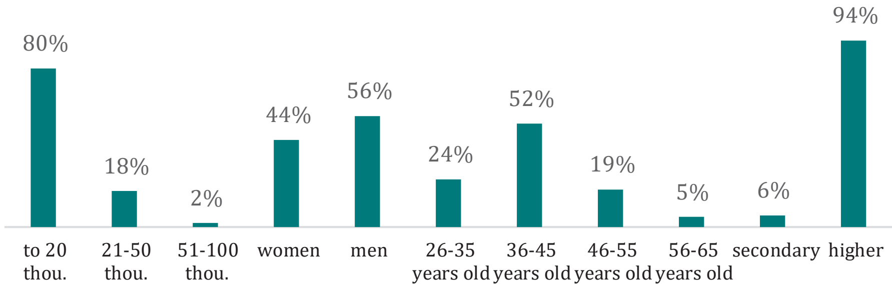

Figure 2. Structure of the research sampled- data provided by municipal road administrators (AMR)

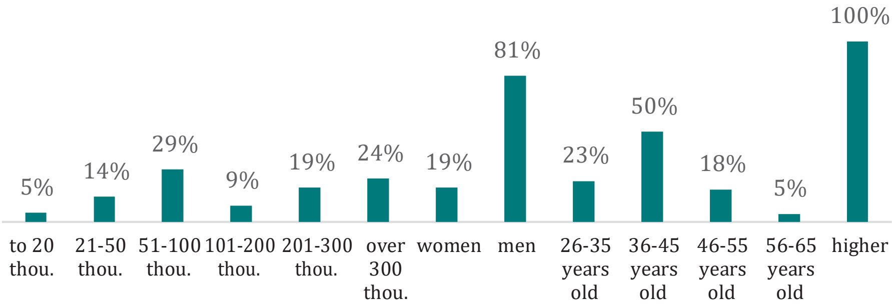

Figure 3. Structure of the research sampled- data provided by the county road administrators (ACR)

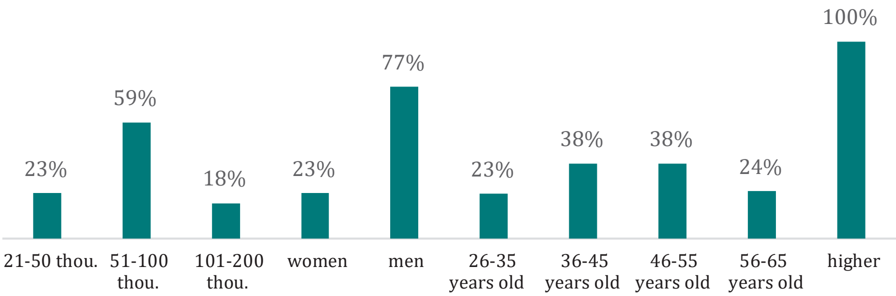

Figure 4. Structure of the research sampled- data provided by the administrators of road network operating within cities with independent country rights (ACCR)

The SPSS software was used to compile the results. The statistical description uses standard measures of descriptive statistics, the eta correlation coefficient, the Chi2 test and the Kruskal-Wallis test. The result was assumed to be statistically significant for $p < 0.05$.

3. Findings

The assessment of the usability of IT tools and their role in making management decisions was based on the analysis of the results of opinion polls of 100 representatives of local government managers acting as road network administrators. Table 1 presents the results of the research in the form of distributions of answers to the question: "Is there an integrated IT system for road infrastructure management implemented at your office?". The type of road administrator was adopted as the grouping variable. In response to this question, 68% of the research sample indicated the answer "no". It is worth noting that the respondents indicated the lack of an integrated IT system in their unit almost ten times more often than the opposite. Interestingly, a group of respondents with access to the above-mentioned system was almost exclusively made up of ACCR representatives, mainly operating in medium-sized cities, i.e., with a population of 51 000–100 000. The Chi2 test indicated the existence of statistically significant differences in the percentage structures of providing answers among the compared groups (x^2 = 34.01 for $p < 0.001$), which means that ACCR units significantly more often provided answers confirming the possession of an IT system than other groups. There were also differences in the answers between the AMR and ACR groups. The results indicate that AMR respondents more often than others chose the answer "no" to the question asked, while representatives of AMR more often answered "I don't know". However, the highest percentage share of responses in this category was recorded among the respondents from the ACCR group.

Table 1. Respondents' answers regarding an integrated IT system to managing road infrastructure, taking into account the surveyed groups of managers

Itemization	Road Managers			Total
	AMR	ACR	ACCR	
No	83.9%	68.8%	22.7%	68.0%
I don't know	14.5%	31.3%	50.0%	25.0%
Yes	1.6%	0.0%	27.3%	7.0%
Total	100.0%	100.0%	100.0%	100.0%

In connection with the aforementioned benefits of using IT systems in business practice, in the next stage of the research it was verified whether there was a relationship between the availability of the IT system and the number of difficulties related to the managed road infrastructure reported by the respondents. The strength of the relationship between these variables was calculated using the coefficient eta, which examines the correlation relationship between the nominal and ratio variable. The results of the research seem to prove the existence of such a relationship. However, it is not too strong, as the eta coefficient was 0.474, and the eta-square value shows that the size of the effect for the described relationship was 22.47%. Focusing only on the answers in the "yes" category, however, it can be noted that the respondents belonging to this category declared a small number of difficulties in the implementation of statutory tasks, or even their absence. In general terms, the average number of responses was 1.71 and was almost two and a half times lower than the number of problems reported by respondents who did not have access to an integrated IT system (4.23).

Next, users were asked to indicate the names of IT systems used in their everyday work. Table 2 lists the IT programs indicated by the study participants, along with a description of their basic functionality. The results indicate that the employees of road administrators use various support systems that are characterised by diverse functionality and usability. Most of the proposed solutions, i.a. SmartGem, RoadMan, Onko3, have a multi-module architecture supporting the activities of managers related to the maintenance and development of the road network. Among the declared solutions, the SmartGem system turned out to be the most popular. It is a comprehensive program for the management of road infrastructure elements allowing for the acquisition, processing and visualization of related data with wide access to thematic modules, including lane records, 3D point cloud, photo-registration, traffic organisation, investments and repairs, etc. The supplier has over 100 completed projects on its account, including a project to implement a comprehensive solution supporting processes related to the maintenance, planning and development of road infrastructure for the Roads and Greenery Management in Gdynia (SF, 2019).

Table 2. Respondents' answers regarding an integrated IT system dedicated to managing road infrastructure, taking into account the surveyed groups of managers (HC, 2022; LP, 2022a, ZUI, 2022; LP, 2022b; TC, 2022; SF, 2022, MD, 2022)

No.	Name	Provider	Description
1.	Onko3	Heller Consult	The software includes a set of tools supporting decision-making related to the implementation of maintenance programs and comprehensive Asset Management plans. The software unifies and verifies the available data, and then synchronously presents the information in a visual form, i.e., on maps, line profiles, charts and photos.
2.	LP Portal	Lehmann+Partner	An application available in the form of a subscription service, providing access to key data and executive processes carried out on the road network from any device equipped with a web browser.
3.	RoadMan	Lehmann+Partner	Modular software with a wide range of functionalities supporting road managers in supervising roads and bridges, including creating traffic organization projects, generating Road Book reports and a real image of the road corridor.
4.	EwiDr	ZUI S. Kowalski	Software dedicated to keeping a road record system, including an inventory of the road network, keeping a road book, detour logs, creating technical and operational maps.
5.	SIBView 5	Vectra Poland Company	Software supporting the management of roads and bridges, consisting of, e.g., the road network browser, interactive map, line plan, database with filtering tools and report generation functions.
6.	Pasaż	TransComp	A tool dedicated to supporting the manager's work in the area of occupancy of the right-of-way.
7.	SmartGEM	Smart Factor	A comprehensive system for managing elements of road infrastructure that allows for the acquisition, processing and visualization of related data with broad access to thematic modules, e.g., record of the right-of-way, 3D point cloud, photo registration, traffic organization, investments and repairs, etc.
8.	GIS ROAD	MAX Drogi	Software operating with the use of GIS technology and consisting of modules for recording roads, bridges and culverts, inspections of the technical condition of roads and interactive overview maps.

Respondents assessed the systems they indicated according to the scale of their usefulness understood as the degree of usefulness of a given system in the daily management of the road network. Overall, the average rating on a 7-point scale was 5, indicating a rather high level of user satisfaction with the IT support resulting from access to the system. The research results indicate that the SibView5 program, which is currently available to two road administrators, turned out to be the system with the highest utility, in both cases with a score of 6, thus proving its high practical usefulness.

The results of the research indicate that the use of IT systems by road administrators is rather limited and in practice comes down to the use of a small number of modules designed to perform specific tasks. Their average number in the sample was 1.85 with a dominant of 2. The most frequently used modules utilised in the discussed units include database elements related to data management in the form of storage, analysis and reporting of historical, current and projected, as well as their use for the needs of the road network inventory.

Respondents who did not have access to an integrated IT system were asked to specify the need to implement it at their workplace. The percentage of summed answers in the "yes" category for this variable was 39.7%, and negative answers – 46.0%. The average rating was 3.95. It was therefore slightly below the neutral answer "neither yes nor no". It was not noted that the respondents' answers were determined by the place of conducting management activity (H = 2.83 for $p > 0.05$). Readiness to implement a new system is, to some extent, conditioned by answers related to the use of other IT tools at work. It turns out that the need to implement an integrated IT system in their unit is more often felt by the respondents who have experience in working with IT programs (51.6%) than the respondents without such practice (44.6%). The Chi2 test showed statistical significance at $p < 0.01$.

Tables 3–4 present the distribution of answers to the questions on conducting a road life cycle cost analysis (LCCA) and collecting data on the road network using photo-scanning/metric photo-registration with the use of cameras, which in practice require support with IT applications. The grouping variable in both cases was the type of road administrator. In the case of the first question, the percentage of negative answers turned out to be very high and amounted to 86.0% of all declarations. Respondents using the LCCA method constituted only 1% of the research sample, and no opinion on this subject was indicated by 13% of the survey participants. Analysing the data, it can be seen that there were significant differences in responses between the compared groups (x^2 = 10.71 for $p < 0.05$). Compared to the first two groups, ZDM respondents were less likely to give negative answers. In turn, AMR respondents, less often than other groups, preferred to indicate neutral answers.

Table 3. Respondents' responses to the use of road life cycle cost analysis (LCCA) taking into account the surveyed groups of managers

Itemization	Road Managers			Total
	AMR	ACR	ACCR	
Yes	0.0%	0.0%	4.5%	1.0%
I don't know	6.5%	18.8%	27.3%	13.0%
No	93.5%	81.3%	68.2%	86.0%
Total	100.0%	100.0%	100.0%	100.0%

Table 4. Respondents' answers regarding the collection of data on the road network by means of photo-scanning/metric photo-registration with the use of cameras, taking into account the surveyed groups of administrators

Itemization	Road Managers			Total
	AMR	ACR	ACCR	
Yes	50.8%	80%	45.5%	54.1%
I don't know	0.0%	0.0%	13.6%	3.1%
No	49.2%	20.0%	40.9%	42.9%
Total	100.0%	100.0%	100.0%	100.0%

On the other hand, the results of research concerning the collection of data on the road network by means of photo-scanning/metric photo-registration with the use of cameras look better, which can be largely explained by the need for road administrators to meet time-consuming documentation requirements. The research shows that the majority of respondents acquire spatial data using the analysed solutions (54.1%), but the percentage of negative answers also turned out to be high, as it exceeded 40%. Analysing the distribution of answers to this question, it can be seen that the percentage of negative answers was the highest among AMR respondents (49.2%), while the highest percentage of confirming answers was recorded in the case of ACR respondents. Chi2 test ($x^2 = 15.07$) showed statistical significance at $p < 0.01$.

Conclusions

The article deals with the problem of usability of IT systems in the management of road assets, paying particular attention to issues related to their practical application in the activities of local government units, which act as managers for almost 90% of national roads (STAR, 2022). The picture that emerges from the research, however, is bleak. It turns out that, regardless of their advantages, few administrators use integrated IT systems in practice to make decisions related to the maintenance and development of the road network. The results of the study indicate the diversified situation among the comparative groups in this respect. The data show that the use of IT systems is declared almost exclusively by representatives of ACCR, i.e., road administrators who combine the features and tasks of both the municipality and the county. Perhaps a similar phenomenon occurs here as in the case of typical business activity, where the implementation of IT systems is mainly associated with the sector of large enterprises (Tasnawijitwong & Samanchuen, 2018). However, there may be many reasons for this situation and they may be different for each administrator. Interestingly, the need to implement an IT system in their unit is felt mainly by respondents who have experience in working with digital programs. People without such experience, on the other hand, feel more resistance to change, most likely they are not sure whether it will be a change for the better.

It is worth noting that the results of the research indicate a fairly high level of satisfaction of the respondents with regard to the use of IT systems, most likely resulting from their practical use and related experiences. However, it should be emphasised that satisfaction in terms of the usefulness of IT systems was diagnosed only among a small group of the research participants. This group uses various support systems that are characterised by diverse functionality and usability, and the most popular solution turned out to be the SmartGem system. In practice, however, the use of IT systems is rather limited and mainly boils down to the use of a small number of modules intended for the implementation of selected tasks. It seems that the operation of IT systems is mainly used at the level of operational work related to the implementation of ongoing maintenance activities, excluding the possibility of using information technology in strategic management. They include activities aimed at optimizing funds for the maintenance of road infrastructure, selecting maintenance and investment strategies, and taking actions aimed at achieving an appropriate level of services provided, taking into account environmental and social aspects, as well as issues related to risk management.

It should be noted that the research results show a positive correlation between the fact of using the IT system and the number of difficulties related to the road infrastructure under their management, as reported by the respondents. Although the dependence found was not too strong, and the use of the IT system explained slightly more than 20% of the variability of results related to irregularities, the results of the research demonstrated that users of IT systems struggled with fewer errors than respondents without such access. This, in turn, may prove measurable benefits from the adopted solutions related to digital transformation, although one should be aware of other factors that may reveal an even stronger relationship in the considered area. In the authors' opinion, this is an interesting cognitive area that requires verification in future research.

In addition, it is extremely rare for road administrators to make decisions based on the results of the LCCA analysis. These are quite surprising results if we consider that the LCCA study is currently one of the most popular methods used to assess the effectiveness of road infrastructure management, thanks to which the road manager can assess the long-term economic benefits between competing, alternative activities (NA, 2017). Perhaps, this is due to the lack of access to appropriate analytical tools. In such a situation, the Federal Highway Administration (FHWA) software called RealCost may be helpful, containing a set of tools for conducting an LCCA in the selection of the right type of road surface. The FHWA recommends five research steps that include: identifying design alternatives, defining a timetable, estimating costs, calculating life cycle costs, and analysing the result (FHWA, 2021). The researchers point out that a decision regarding a choice of a suitable type of road asset is very important already in the pre-investment phase (Beran et al., 2016).

Summarising the results of the research, it is worth noting one more aspect of the problem resulting from the failures of implementation works, which, as research shows, can be explained by the lack of awareness of the complexity of such an undertaking (Coşkun et al., 2022; Stabryła & Wawak, 2012). In practice, the implementation of the system requires significant expenditure on its design, construction and maintenance, as well as applications supporting the planning and control of all processes. This is often accompanied by the resistance of employees resulting from the mannerisms and habits acquired in the current line of work, as well as from the fact that they are unfamiliar with the new system. The literature on the subject provides examples of failed or partially failed implementations. Such an example is presented in the *Compendium of Best Practices in Road Asset Management*, where the authors point out that in many countries the implementation of an IT system in road administration ended in failure (ADB, 2018). This resulted from the employees' inability to meet high requirements of new work organisation, especially with regard to the broadly understood process of data processing and analysis.

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