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The application of information systems in passenger-car operation management: an analysis of the performance of start-stop and cruise control

Zastosowanie systemów informatycznych w kontekście zarządzania eksploatacją pojazdów osobowych na przykładzie analizy działania systemu start-stop i tempomatu

Abstract. The article addresses the issue of applying modern information systems in the automotive industry. The aim of the research was to determine the effectiveness of two driver-assistance systems – start-stop and cruise control – in the context of average fuel consumption. The study was conducted under real conditions on three passenger cars of different brands and production years. The analysis covered driving in urban and extra-urban traffic, with measurements of fuel consumption taken both with and without the use of the examined systems. The results indicate that the application of the start-stop system in urban traffic contributes to fuel consumption reduction, while the use of cruise control in extra-urban traffic supports fuel savings in selected vehicles. The obtained results confirm the validity of implementing modern information solutions in the automotive sector, both from an economic and environmental perspective. The article fits into the research trend concerning the use of information technologies in managing the quality of logistics processes related to vehicle operation and in improving driver-assistance systems.

Keywords: information systems, automotive industry, start-stop, cruise control, fuel consumption, management, logistics, vehicle operation

Synopsis. Artykuł podejmuje problematykę zastosowania nowoczesnych systemów informatycznych w branży motoryzacyjnej. Celem badań było określenie efektywności działania dwóch systemów wspomagających kierowcę – start-stop oraz tempomatu – w kontekście średniego zużycia paliwa. Badania przeprowadzono w warunkach rzeczywistych w odniesieniu do trzech samochodów osobowych różnych marek i roczników. Analizie poddano przejazdy w ruchu miejskim oraz poza-

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miejskim, dokonując pomiarów zużycia paliwa przy wykorzystaniu i bez wykorzystania badanych systemów. Wyniki wskazują, że zastosowanie systemu start-stop w ruchu miejskim przyczynia się do obniżenia spalania, natomiast użycie tempomatu w ruchu pozamiejskim sprzyja redukcji zużycia paliwa w wybranych pojazdach. Uzyskane rezultaty potwierdzają zasadność implementacji nowoczesnych rozwiązań informatycznych w motoryzacji, zarówno z perspektywy ekonomicznej, jak i środowiskowej. Artykuł wpisuje się w nurt badań nad wykorzystaniem technologii informatycznych w zarządzaniu jakością procesów logistycznych związanych z eksploatacją pojazdów oraz doskonaleniem systemów wspomagających kierowcę.

Słowa kluczowe: systemy informatyczne, branża motoryzacyjna, start-stop, tempomat, zużycie paliwa, zarządzanie, logistyka, eksploatacja pojazdów

JEL codes: L91, R49

Introduction

The dynamic development of information technologies in recent decades has substantially reshaped the operations of contemporary enterprises and fostered new management models. The automotive industry – one of the most innovative sectors of the economy – has been a particularly intensive field of implementation for modern ICT solutions. Digitalization spans both the organizational layer – manifested in ERP, CRM, and decision-support systems – and the technical layer, linked to the advancement of onboard mechatronic and electronic systems that support the driver [Seppänen 2025].

The literature emphasizes the dual nature of this digitalization. First, it concerns the optimization of intra-organizational logistics processes, such as production planning, logistics, and quality management. Second, it pertains to the integration of advanced in-vehicle systems whose role is to enhance safety, comfort, and fuel economy. The growing prominence of onboard systems is aligned with the Industry 4.0 paradigm and the transition of automotive transport toward sustainable mobility, in which data and process management play a pivotal role [Albrecht et al. 2024].

In this context, advanced driver-assistance systems (ADAS) are of particular importance. They not only raise the level of active safety but also affect vehicle operation and user experience. Among these solutions are the automatic engine start-stop system, which shuts down and restarts the engine during brief halts, and cruise control, which maintains a target vehicle speed under extra-urban driving conditions. Both systems are widely implemented in passenger cars and exemplify the practical application of information technologies in the automotive domain, with direct implications for the management of in-service vehicle operations [Tortorelli 2025].

From the standpoint of management and logistics sciences, investigating the effectiveness of such solutions is highly consequential. Verifying the actual impact of start-stop systems and cruise control on fuel consumption enables an assessment not only of their economic effects but also of their environmental consequences and their influence on the quality of operational processes – thereby informing decision-making in fleet management and the advancement of vehicle technologies.

The aim of this article is to examine the influence of the start-stop system and cruise control on average fuel consumption in selected passenger cars of various makes and model years. The empirical study was preliminary in nature and focused on differences between urban and extra-urban driving conditions. The contribution situates itself within the stream of research on the use of information systems in managing logistics processes associated with vehicle operation and on the refinement of driver-support technologies in automotive practice [Gao 2024].

The development of information systems in enterprise management, including in the automotive industry, constitutes one of the key areas of the contemporary economy and is a cornerstone of the Industry 4.0 concept [Dabic-Miletic 2023]. These systems have been framed in the literature in various ways, including as "management support systems" and "information systems for management". Their overarching goal is to acquire, store, and process information in such a way that it can serve as a basis for effective managerial decision-making. As emphasized by Bielecki, Chmielarz, as well as Kapczyński and Smugowski, information systems should be treated as an integral part of the organization, determining the quality of its functioning [Bielecki 2001; Chmielarz 2000; Kapczyński i Smugowski 2010, p. 28]. Klonowski indicates that the role of information systems in management stems from their ability to combine data from different areas of activity and transform them into knowledge necessary for decision-making [Klonowski 2004].

Today, the most advanced form of enterprise digitalization remains integrated systems, which encompass many functional modules and provide comprehensive support for management processes.

ERP and ERP II systems occupy an important place in the literature. Parys [2006] emphasizes that their purpose is the full integration of financial data, human resources, and production processes, which allows not only for the optimization of a company's internal processes but also for better integration with its economic environment. Majerski [2012] indicates that ERP systems constitute a key tool for managing logistics and production, enabling the planning, monitoring, and control of process flows.

The implementation of ERP systems brings measurable benefits in cost reduction, improvement of data quality, and increased organizational flexibility. Auksztol and co-authors emphasize that ERP systems, exemplified by SAP, enable better management of relationships with customers and suppliers and increase the transparency of processes [Auksztol, Balwierz, Chomuszko 2012]. The literature indicates that these systems contribute to improving customer service quality by better aligning operational activities with market expectations.

In the context of Industry 4.0, Gunia notes that contemporary information systems should ensure interoperability and rapid response within supply networks, which is particularly important in the automotive industry [Gunia 2019]. Also relevant in this area are industry certifications such as VDA and ITA, as well as early-warning systems implemented in ERP-class solutions, which support proactive risk and quality management [Prudhomme et al. 2022].

Examples of systems dedicated to the automotive sector, such as Rekord.ERP and MONITOR ERP, show that integrated solutions enable effective production planning, synchronization of purchasing, warehouse management, time reporting, and full

integration of financial and sales processes [Zalewski 2011; Calamaras 2022]. This directly translates into shorter production cycles, minimized downtime, and improved quality stability.

The most important advantages of the Rekord.ERP system are presented graphically in Figure 1.

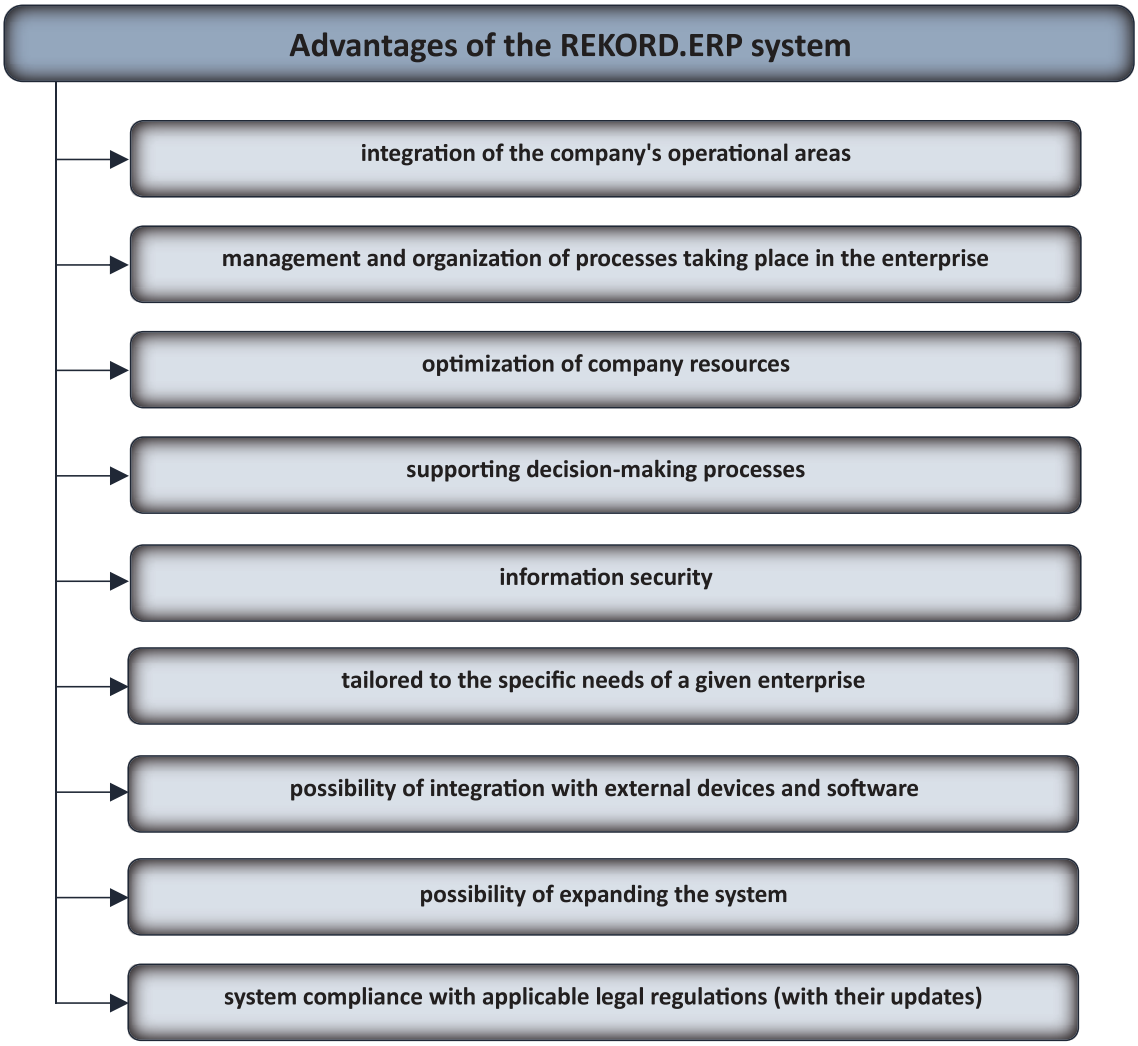

Figure 1. Advantages of the REKORD.ERP system
Rysunek 1. Zalety systemu REKORD.ERP
Source: compilation based on [Wornalkiewicz 2015]
Źródło: oprac. na podst. [Wornalkiewicz 2015]

A parallel strand of research focuses on driver assistance systems (ADAS), which directly affect both active and passive vehicle safety. Herner and Riehl discuss automotive electrical and electronic systems as the foundation for the operation of modern mechatronic solutions [Herner, Riehl 2014]. In turn, Michalski, Gonera, and Janulin indicate methods for assessing the impact of safety systems on vehicle operation and user experience [Michalski, Gonera, Janulin 2012].

Within this domain, systems such as start-stop and cruise control are of particular importance. The start-stop system automatically shuts down and restarts the engine depending on driving conditions, which helps reduce fuel consumption and carbon dioxide emissions, while simultaneously raising questions about the durability of serviceable components and maintenance costs [Wójcik 2019].

The literature also emphasizes the usefulness of microscopic traffic simulations as a tool for supporting transport management and reducing pollutant emissions in medium-sized cities. Brzozowska et al. present a methodology for emission analysis on main arteries using the SUMO platform and a progressive elaboration approach, which allows iterative refinement of the study scope and model parameters under resource constraints. The authors show that testing variants of traffic organization (including signal phase lengths, turning lanes, and "green wave" coordination) prior to implementation makes it possible to achieve smoother flow, shorter travel times, and measurable reductions in emissions (CO, CO_2, NO_x, PM), while simultaneously providing evidence for decision-makers regarding infrastructure modernization and the deployment of ITS as an element of sustainable mobility management [Brzozowska et al. 2021].

In this area, research on telematics and information systems that support continuous improvement processes is also important. Telematics systems implemented in transport enterprises enable not only improved service quality but also more effective fleet management and operational decision-making [Mazurkiewicz 2021; Miler et al. 2020; El Emary 2019; Brzozowska 2019].

Studies on vehicle operation increasingly employ an indicator-based approach that enables the assessment of fleet performance and the safety of transport task execution. As Owczarek emphasizes, an analysis of the operation of 24 delivery vehicles in seven transport companies revealed significant variation in fleet management strategies, and the proposed set of indicators (including working-time utilization, intensity of use, technical readiness, and economic efficiency) can serve as an effective tool to support decision-making in vehicle operation [Owczarek 2024]. The application of such indicators allows transport processes to be monitored, areas requiring improvement to be identified, and strategies to be developed that are oriented toward rational fleet management and enhanced service quality.

The literature increasingly underscores the role of computer simulations as tools that support decision-making in logistics and vehicle operation management. Simulations make it possible to model real transport operations, evaluate alternative scenarios, and forecast long-term impacts on costs and the environment. They are used, among other things, for route planning, fleet management, warehouse optimization, and assessing the impact of vehicle operation on emissions. Thanks to such solutions, enterprises can test new technologies and processes without incurring the costs of real-world implementation, which supports both economic efficiency and the achievement of sustainable development goals [Ługiewicz, Wierzbicki 2025].

The body of literature demonstrates that the development of information systems, ranging from ERP-class solutions to onboard ADAS, creates a coherent data ecosystem that strengthens enterprises' capacity for quality management, process optimization, and building competitive advantage. Nevertheless, questions remain open regarding the actual impact of selected driver-assistance systems on the economics of vehicle operation and the qualitative aspects of their use.

Research questions

1. To what extent does the application of the start-stop system affect average fuel consumption under urban traffic conditions?
2. Does the use of cruise control under extra-urban driving conditions allow for a significant reduction in fuel consumption?
3. What differences in the effectiveness of start-stop and cruise control systems can be observed in vehicles of different makes and model years?

Materials and methods

The purpose of the conducted research was to determine the impact of selected modern information systems used in passenger cars – the start-stop system and cruise control – on average fuel consumption under diverse traffic conditions. The study was empirical in nature and focused on analyzing the effectiveness of these systems in real operating conditions, taking into account both urban and extra-urban traffic.

In formulating the research assumptions, a main hypothesis was adopted according to which the use of driver-support information systems contributes to reducing fuel consumption, and thus to improving the economics and ecology of vehicle operation. Within the study, specific hypotheses were also advanced.

The first assumed that the use of cruise control under extra-urban driving conditions leads to a decrease in average fuel consumption. The second hypothesis concerned the impact of the start-stop system and assumed that its operation in urban traffic, characterized by frequent stops, results in a reduction of average fuel consumption. The third hypothesis related to differences between particular vehicle brands, indicating that the effectiveness of the systems under investigation may vary depending on the design solutions employed.

The objects of the study were three passenger cars of different makes and model years, purposively selected due to their varied levels of technical advancement and equipment. The sample included: an Audi A4 from 2014, a BMW X4 from 2017, and a Skoda Octavia II from 2012. Each vehicle was equipped with a set of safety and driver-assistance systems, yet differed in terms of the implementation of the solutions under study. This made it possible to carry out a comparison under controlled conditions while simultaneously reflecting real road situations (Figure 2).

The research experiment was conducted in two traffic environments. Extra-urban conditions were reproduced on the Częstochowa–Ładzice route with a length of 41.6 km, whereas urban conditions were modeled on the section of Jana Pawła II Street and Aleja Wyzwolenia in Częstochowa, characterized by the presence of numerous traffic lights. In each variant, average fuel consumption was measured both with the examined system switched on and with it switched off. Measurements were taken using onboard computers that enabled real-time monitoring of fuel consumption values. Each run was repeated twice in order to limit the influence of random factors and increase the reliability of the data obtained.

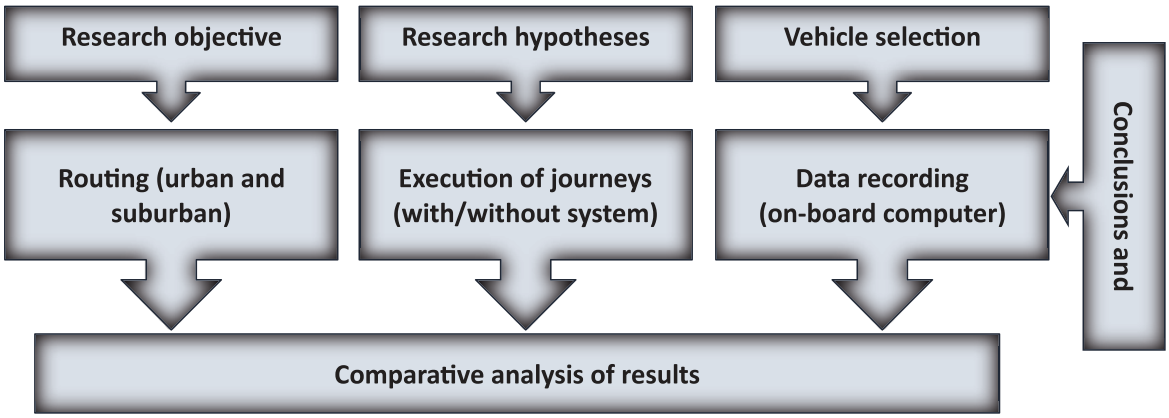

Figure 2. Schematic diagram of the research methodology for the start-stop and cruise control systems

Rysunek 2. Schemat metodyki badań nad systemami start-stop i tempomat

Source: own study

Źródło: badania własne

In the research process, an experimental method was applied, the essence of which was to compare results obtained under controlled conditions differing only in the use of the given system. To maintain result consistency, the driver participating in the study also recorded additional circumstances that could affect the measurements, such as traffic intensity and weather conditions. The collected data were subjected to comparative analysis, relating mean values to catalog data provided by manufacturers.

The results were compiled in tabular form, which made it possible to juxtapose differences between fuel consumption with the systems engaged and the values achieved in their absence. The analysis also made it possible to determine the extent to which the examined solutions contribute to improving the efficiency of vehicle use. It should be emphasized that the research was preliminary in nature and was limited to a small number of vehicles, which constitutes a certain limitation on the generalizability of the findings. Nevertheless, the results provide important empirical material that allows conclusions to be drawn regarding the potential benefits arising from the implementation of start-stop and cruise control systems in passenger cars. Given the preliminary nature of the study, a simplified measurement model was adopted, focused on analyzing differences in fuel consumption when using the start-stop and cruise control systems.

Research results

The conducted research aimed to verify the adopted hypotheses regarding the impact of the start-stop system and cruise control on fuel consumption in selected passenger cars. Three vehicles of different makes and model years were analyzed: an Audi A4 (2014), a BMW X4 (2017), and a Skoda Octavia II (2012), and their equipment, including modern systems, together with the year of manufacture, is presented in Table 2. These vehicles differed in their level of technological advancement, which made it possible to capture potential divergences in the effectiveness of the systems under study.

The research was carried out in two operational environments. The first was the extra-urban route Częstochowa–Ładzice (Table 1) with a length of 41.6 km (Figure 3), while the second was the section of Jana Pawła II Street and Aleja Wyzwolenia in Częstochowa (Figure 4), characterized by numerous traffic lights and frequent vehicle stops. Each run was performed twice: with the examined system engaged

Table 1. Average fuel consumption on the Częstochowa–Ładzice route
Tabela 1. Średnia zużycia paliwa na trasie Częstochowa–Ładzice

Brand and model	Manufacturer-rated average fuel consumption [l/100 km]	Average fuel consumption without cruise control [l/100 km]	Average fuel consumption with cruise control [l/100 km]
Audi A4	6.2	7.0	6.5
BMW X4	7.4	8.5	7.6
Skoda Octavia II	6.5	6.7	6.8

Source: compilation based on the author's own research
Źródło: oprac. własne autora

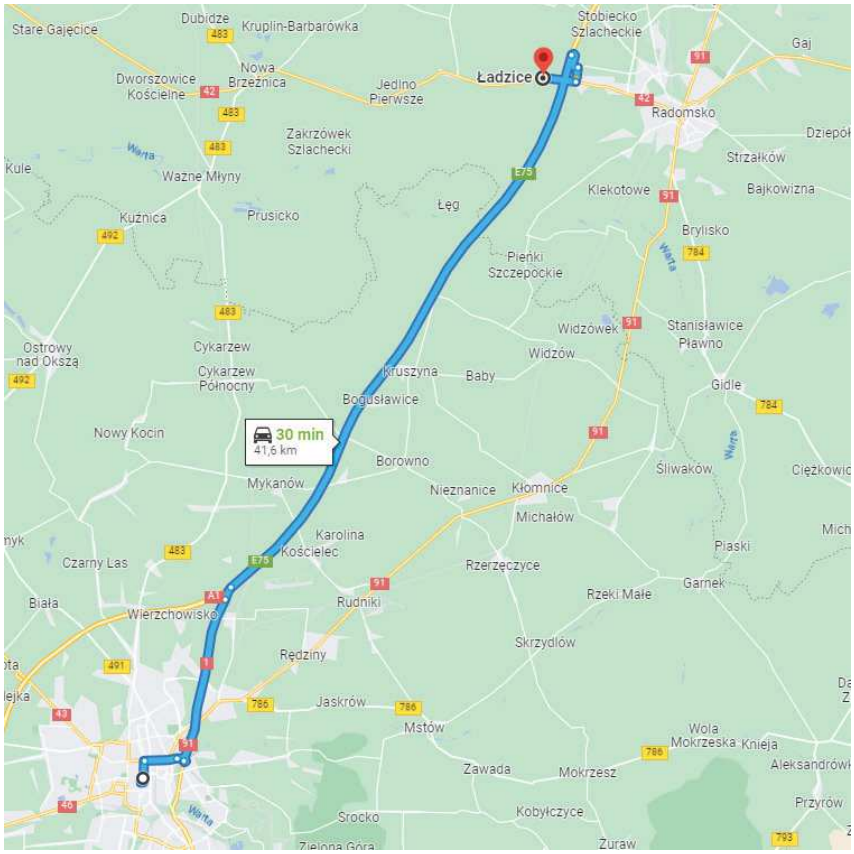

Figure 3. Map showing the Częstochowa–Ładzice route
Rysunek 3. Mapa z wyznaczoną trasą Częstochowa–Ładzice
Source: Google Maps [accessed: 24.08.2025]
Źródło: Mapy Google [dostęp: 24.08.2025]

(start-stop or cruise control) and without its use, which made it possible to compare reference values. Measurements were taken using onboard computers that recorded average fuel consumption. Under urban driving conditions, the start-stop system proved most effective in the BMW X4 (2017), where a decrease in average fuel consumption of about 0.4 l/100 km was recorded compared to the run without the system. In the Audi A4 (2014), the difference was slightly smaller and amounted to 0.2 l/100 km, whereas in the Skoda Octavia II (2012), the effect of the system was least noticeable, which may result from a lower level of advancement of the applied solutions. The average fuel consumption for this section with the start-stop system applied is presented in Table 2. These results confirm the hypothesis that the start-stop system, particularly under urban conditions, contributes to reducing fuel consumption, although the magnitude of this effect depends on the vehicle's design.

Under extra-urban driving conditions, the impact of cruise control operation was analyzed. In the case of the BMW X4, the use of the system made it possible to maintain a constant speed and resulted in a reduction in fuel consumption by 0.3 l/100 km.

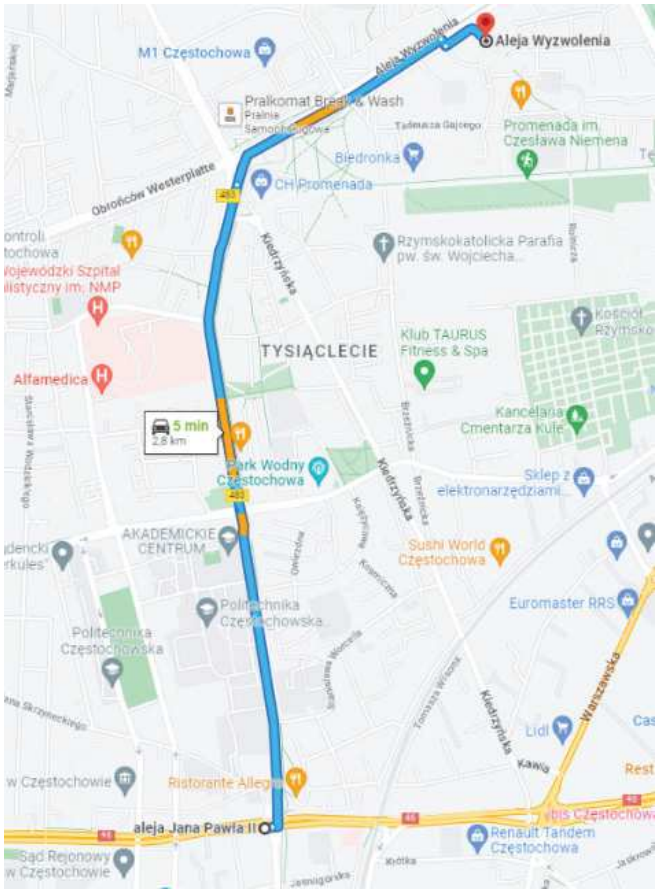

Figure 4. Map with the designated route in the city of Częstochowa within the area of Jana Pawła II Street and Aleja Wyzwolenia

Rysunek 4. Mapa z wyznaczoną trasą na terenie Częstochowy w obrębie ulic Jana Pawła II i Alei Wyzwolenia

Source: Google Maps [accessed: 24.08.2025]

Źródło: Mapy Google [dostęp: 24.08.2025]

Table 2. Average fuel consumption on the Częstochowa–Ładzice route
Tabela 2. Średnie zużycie paliwa na trasie Częstochowa–Ładzice

Brand and model	Manufacturer--rated average fuel consumption [l/100 km]	Average fuel consumption in urban conditions without the start-stop system [l/100 km]	Average fuel consumption in urban conditions with the start--stop system [l/100 km]
Audi A4	6.2	8.5	8.2
BMW X4	7.4	8.8	8.6
Skoda Octavia II	6.5	7.0	6.8

Source: compilation based on the author's own research

Źródło: oprac. własne autora

The Audi A4 recorded a reduction of 0.2 l/100 km, whereas the Skoda Octavia did not exhibit significant differences, which may result from design constraints and the absence of advanced algorithms governing system operation. The results indicate that cruise control supports driving economy, particularly in newer-generation vehicles; however, its effectiveness is not uniform across all makes and models.

Discussion

The comparative analysis confirmed that both the start-stop system and cruise control can have a real impact on reducing fuel consumption, and thus on the economics of vehicle operation. The effects of both systems, however, are differentiated and on both traffic conditions and the design specifics of the vehicle under study. The research also showed that actual savings are lower than the values declared by manufacturers, which indicates the need for further empirical work under real-world operating conditions.

From the perspective of management and logistics, the results confirm the importance of implementing information systems not only for driving safety and comfort, but also for optimizing operating costs. These findings may form the basis for decision-making in fleet management and for enhancing solutions aimed at improving energy efficiency and reducing emissions.

The research results obtained confirm the thesis that modern information systems used in passenger cars can perceptibly affect the economics of operation. The start-stop proved particularly effective under urban driving conditions, which is consistent with literature data indicating the potential to reduce fuel consumption and CO_2 emissions by shutting off the engine during stops. At the same time, it should be noted that the scale of savings in real conditions was smaller than that declared by manufacturers, which is confirmed by earlier observations of researchers analyzing mechatronic systems in the automotive domain [Caban et al. 2017].

Cruise control, whose task is to maintain a constant speed, showed the highest effectiveness under extra-urban driving conditions. The results of the present study indicate a reduction in fuel consumption on the order of 0.2–0.3 l/100 km, which corroborates

the views of authors analyzing the impact of cruise control on driving economy [Sobczak et al. 2017]. It is worth emphasizing, however, that in older-generation vehicles this system did not yield significant savings, which demonstrates that its effectiveness depends on the vehicle's design and on the algorithms that govern its operation.

An important conclusion arising from the research is that the impact of the systems under study on fuel consumption varies depending on the vehicle's make and model year. These results are consistent with the literature, according to which modern information systems must be analyzed in the context of interoperability and the degree of integration with other electronic subsystems of the vehicle [Gunia 2019]. In practice, this means that potential savings depend not only on the mere application of the system but also on the quality of managing its implementation across vehicles of different classes.

Verification of the actual impact of start-stop and cruise control systems on fuel consumption provides information not only on potential economic benefits for individual users, but also on opportunities to optimize costs in fleet management. Reduced fuel burn directly translates into lower operating costs, improved energy efficiency, and progress toward sustainable development strategies.

The results obtained fit within the broader context of the energy-climate transition, in which the transport sector plays a key role. As Gołąbeska and Harasimowicz [2023] emphasize, implementing sustainable development policies and the assumptions of the European Green Deal requires not only moving away from conventional energy sources, but also consistently reducing emissions in the mobility domain. Technical and organizational solutions that enable the rational use of energy and the reduction of CO_2 emissions are of particular importance here, aligning with broader low-emission economic strategies. The findings of this study show that even seemingly minor innovations, such as the start-stop system or cruise control, can contribute to achieving the objectives of the European Green Deal while simultaneously supporting fleet management in the spirit of sustainable development [Jeżowski 2017, pp. 69–83].

Information systems in the automotive sector can constitute an important component of quality management for operational processes. They confirm the potential of technology to improve the economics of driving, while at the same time drawing attention to the need for further empirical studies that include a larger number of vehicles and a broader spectrum of road conditions.

It is worth emphasizing that the significance of information systems in the automotive industry should also be analyzed in the context of Industry 4.0. This concept is based on technologies such as the Internet of Things, big data, digital twins, cyber-physical systems, and artificial intelligence, which enable full integration of production and operational processes. In practice, this entails a shift from simple driver-support solutions to comprehensive systems for managing logistics and operational processes at the scale of the entire enterprise. In line with the Business Process Management (BPM) approach, digital technologies become tools for identifying, modeling, and improving processes, which makes it possible not only to enhance the efficiency of an individual vehicle's driving, but also to optimize costs, emissions, and service quality at the fleet scale [Dostatni, Rojek 2024].

Summary and conclusions

The conducted study made it possible to verify the adopted hypotheses concerning the impact of the start-stop system and cruise control on average fuel consumption in passenger cars. The analysis of the results showed that the start-stop system, particularly under urban driving conditions, contributes to a reduction in fuel consumption, whereas cruise control proved most effective during extra-urban driving. However, the magnitude of the savings obtained varied depending on the vehicle's make and model year, which indicates the important role of technical design and the quality of system implementation.

From the perspective of fleet management in enterprises, these observations translate into three practical implications: (1) where urban driving predominates, vehicles with efficient start-stop systems (or hybrids) should be a purchasing priority, (2) on extra-urban and motorway routes, benefits are provided by a constant-speed strategy supported by eco-driving training and policies limiting unnecessary acceleration/braking, (3) fleet decisions should be made on the basis of real operating data (OBD loggers/telemetry), as these best reflect the effects of technology for a given vehicle-use profile. Incorporating these principles into a quality management system for transport processes makes it possible to sustainably reduce costs and emissions while simultaneously increasing operational predictability [Merkisz 2010, pp. 115–127].

The research results confirm the importance of modern information systems as tools supporting the process of optimizing operations. The data obtained can be used in the process of fleet management, where reduced fuel consumption directly translates into lower operating costs and increased energy efficiency. They also have an environmental dimension, supporting the implementation of sustainable development strategies and corporate social responsibility.

The conclusions drawn from the study allow several practical implications to be formulated. First, the implementation of start-stop and cruise control should be treated as an element of a broader process of managing the quality of vehicle operation, in which not only costs are analyzed, but also user comfort and environmental impact. Second, fleet managers should take into account the differentiated effectiveness of the systems studied depending on the vehicle's make and model year, adjusting investment policy and purchasing strategy to actual utility effects. Third, vehicle manufacturers should undertake actions aimed at improving the algorithms governing system operation so that their effectiveness is as high as possible under different road conditions.

In summary, the study confirms that the application of modern information systems in the automotive sector has not only a technological dimension but also a managerial one. These systems fit into processes of quality management, cost reduction, and building competitive advantage in the automotive industry. The conducted research is preliminary in nature and covers a limited sample of vehicles. Therefore, the results should be regarded as a starting point for further analyses involving a larger number of cars representing different brands, classes, and operating conditions. Future studies should also extend the scope of analysis to include environmental aspects in order to obtain a comprehensive picture of the effectiveness of driver assistance systems.

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