

THE COSTS OF “VISION ZERO”. WHEN WILL INFRASTRUCTURAL INVESTMENTS IN AUTOMATED MOBILITY PAY OFF?

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Abstract. Road safety continues to be a major international concern, with approximately 1.19 million fatalities and up to 50 million injuries occurring annually. In response, the European Union and the United Nations have launched ambitious strategies like “Vision Zero” and the Decade of Action for Road Safety (2021–2030), aiming to drastically reduce or eliminate traffic-related deaths. Countries such as Poland have shown measurable progress, achieving a 35% reduction in fatalities and a 29% decline in total accidents since 2019. As human error remains the dominant cause of traffic accidents, autonomous vehicles (AVs) are being considered a transformative solution. AVs are expected to eliminate typical driver mistakes such as distraction, fatigue, and impaired judgment. However, their deployment requires substantial investment in digital infrastructure, such as V2X and C-V2X communication, HD maps, and 5G networks. This study estimates and compares the annual cost of road accidents caused by human error (EUR 11.13 billion) with the infrastructure investments needed to support AVs in Poland. Based on population density modelling, the number of intersections was estimated at 1.9 million, leading to a V2X deployment cost of EUR 140.1 billion. Adding HD mapping (EUR 1.84 billion) and 5G rollout (EUR 2 billion), the total estimated investment is approximately EUR 143.94 billion. Assuming AVs fully eliminate human error, the investment could be recouped in about 13 years through accident cost savings. While based on simplified assumptions, this initial analysis highlights the potential long-term value of AV

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implementation in achieving road safety objectives and reducing economic losses from traffic incidents.

Keywords: autonomous vehicles, automation, human error, infrastructure investment, road safety, Vision Zero.

Introduction

The issue of high accident rate has been raised internationally for years. Governments of individual countries have been conducting successive campaigns encouraging careful driving, but the statistics have not been promising. World Health Organization is alarming that approximately 1.19 million people a year lose their lives as a result of a road traffic crash. About 20–50 million (depending on country, severity rate, etc.) more people suffer non-fatal injuries, with many incurring a disability (World Health Organization, 2023).

Therefore, a concept of Vision Zero – a road safety strategy aiming to eliminate all traffic fatalities and severe injuries was established. The EU's long-term goal is to move as close as possible to zero fatalities in road transport by 2050 (European Commission, 2020). A closer and easier to achieve goal was set in September 2020 by the United Nations (UN). Adopting a resolution A/RES/74/299 "Improving Global Road Safety", proclaiming the Decade of Action for Road Safety 2021–2030, the UN aspired to halve the number of fatalities and injuries by 2030 (World Health Organization, 2020).

In March 2025, the European Commission published preliminary figures for road fatalities in 2024, showing a decrease by approx. 3% comparing to 2023, equating to 600 fewer lives lost, what means a decrease of 13% comparing to 2019. Although this represents progress, the rate of improvement is slow, and a majority of Member States are not on course to achieve the target. On the other hand, based on preliminary data, Bulgaria, Denmark, Lithuania, Poland and Slovenia are said to be on track to meet the 50% reduction in road deaths and serious injuries by 2030, reaching 24%, 27%, 34% and 34% decrease, respectively (European Commission, 2025). In April 2025, the Polish Observatory of Road Safety published a report showing that Poland achieved astonishing 35% reduction of fatalities, 30% of injuries (including – 27% severe injuries), and 29% decrease in the number of total accidents (comparing to 2019, based on Accident data – Police Headquarters SEWiK database) (Polish Road Safety Observatory, 2025).

The result obtained helped save many lives, which is the primary value, but also reduce the expenditure incurred by the state. The estimated costs of road accidents depend on many factors, such as the type of accident, the number of people injured, the extent of property damage, the length of rehabilitation, the costs of treatment, as well as the costs associated with seeking justice (e.g., lawsuits).

Creating a safe road environment for all users is therefore extremely crucial. Human life is precious and should be protected by any means. Apart from introducing new, stricter laws, the European Union begins to focus on vehicle safety. The General Safety Regulation (GSR) is an EU package of regulations aimed at improving road safety by standardising equipment in vehicles (Regulation 2019/2144). Recognising that while human error is inevitable, the system should be designed to minimise its impact. This surely played an important role in reducing the number of accidents.

A step forward is an introduction of highly automated vehicles (AVs), which aim to eliminate human-caused accidents. In their review paper, Almaskati et al. (2023) found evidence supporting the hypothesis that widespread adoption of this technology had the potential to significantly reduce traffic accidents and injuries. On the other hand, they pointed out that it must be followed by manufacturers' will to prioritise human safety, especially in scenarios involving different road users. Moreover, datasets published by California Department of Motor Vehicles (2025) support the theory that AVs would improve road safety due to their ability to assess the surrounding environment. However, it is worth noting that even if the technology is mature, AVs may still be involved in accidents – inevitable and requiring ethical decision-making (Naiseh et al., 2025; Shah & Guven, 2025; Singh et al., 2025).

Due to the vast number of statistical data regarding road accidents, many publications on AVs, describing various aspects of their operation, and the lack of detailed investment estimations, it can be difficult for stakeholders to have a thorough understanding of whether it is cost-effective to introduce AVs. Therefore, it is essential to prepare and present an initial assessment of costs regarding the implementation of AVs with relation to expected savings resulting from accomplishing Vision Zero. The aims of this study are to (1) provide an overview of accident-related costs, (2) estimate AV-oriented infrastructure public investments that have to be made by the country, (3) confront the results of (1) and (2) in order to (3) assess estimated cost recovery.

1. Methodology

To accomplish the aims of this paper, a five-step research methodology was developed (see Figure 1). Online search engines such as Google, Google Scholar, Science Direct, and other were used to conduct a preliminary search. Keywords such as "accident-related costs", "autonomous vehicles infrastructure", "autonomous car" were put into the online search engines. Then, for each component, the author tried to find cost estimations (meaning pricing); some of them required additional math

operations. Finally, the aggregated costs were compared and conclusions drawn. The author decided to make the consideration for a mother country – Poland.



Figure 1. A five-step research methodology

2. Accident-related costs

The main components that make up the estimated costs of road accidents are (Bai et al., 2025; Jaździk-Osmólska et al., 2024; Pukalskas et al., 2015; Schoeters et al., 2020):

- medical and rehabilitation costs: cost of hospitalization, surgery and medical treatment, cost of rehabilitation for people who have suffered serious injuries, cost of psychotherapy if accident victims need emotional support (however, the last one is rarely reported);
- property damage cost: repair or replacement of vehicles that have been damaged or destroyed as a result of the accident, damage to road infrastructure (e.g., guardrails, road signs, lampposts), costs related to clearing the road and repairing infrastructure;
- losses related to loss of productivity: costs of lost work or reduced productivity of employees who have been injured in the accident, costs related to the need for rehabilitation and temporary incapacity for work;
- legal and administrative costs: costs of police investigations, court investigations and lawsuits, costs of compensation paid to injured parties or their families;
- social costs: the loss of life in road accidents associated with enormous social costs, including family mourning, burial costs and support for the victims' families.

Costs associated with fatal accidents are particularly high and difficult to estimate as it is not possible to value human life; however, the costs of road accidents that result in death include both medical and social costs (e.g., loss of work for those who would have been supported by the victim).

According to SWOV Institute for Road Safety Research (2024), social costs of road crashes in the EU are estimated at 33 billion EUR (19–44 billion EUR), equivalent to 3.4% (1.9–4.6%) of the gross domestic product (based on the Netherlands in 2022). The costs amount to about 7.2 million EUR per road death and 1.2 million EUR per

serious road injury. It results in higher costs than, e.g., traffic congestion (2.7–3.5 billion EUR) or environmental damage (8.2 billion EUR).

In total, in 2022, the costs of road incidents accounted for 1.7% of Poland's GDP₂₀₂₂, including the costs of accidents – 1.2% of GDP₂₀₂₂. According to the report of the Polish Road Safety Council (2025), the costs of road accidents and collisions in 2022 in Poland are provided in Table 1.

Table 1. Road accident costs in Poland in PLN and EUR based on year 2022 (Narodowy Bank Polski, 2025; Polish Road Safety Observatory, 2025)

	PLN	EUR
Total cost of road accidents	37.9 billion	8.9 billion
Unit cost of fatality	2.6 million	0.6 million
Unit cost of seriously injured victim	4.2 million	1 million
Unit cost of slightly injured victim	54.6 thousand	12.8 thousand
Unit cost of road accident	1.8 million	0.4 million
Total cost of road collisions	14.1 billion	3.3 billion
Unit cost of road collision	38.8 thousand	9.1 thousand

3. Infrastructure expenses

Physical components are infrastructure elements that are visible and physically present in public space. Among others these are road signs: vertical, horizontal and traffic lights (including variable message digital signs that change based on conditions, such as the current speed limit or road closure information). Selected prices in 2024, based on data shared by the city of Poznań (Poznań Citizens' Budget, 2024) are change of horizontal thick-layer marking that is 200 PLN/m² (approx. 47 EUR/m²), setting a single pole with a vertical sign 500 PLN (approx. 118 EUR), placing the D-6 "pedestrian crossing" sign against the background of reflective-fluorescent foil 900–1500 PLN (approx. 212–353 EUR), installing an active pedestrian crossing – pulsating light 60 000 PLN (approx. 14 113 EUR).

Additionally, a physical road component is the road itself, i.e., the path used to drive a car that is prepared in a standardised way to tackle the expected purpose and volume. This can be differentiated by category, size, expected traffic volume, importance, and surface. The expenses of building a new road vary from 400 000 PLN (approx. 94 000 EUR) to 1,5 billion PLN (approx. 0,35 billion EUR) for 1 km (Nowak, 2024). The city of Puszczykowo revealed that the cost of road renovation is 250 PLN (approx. 60 EUR) per m² (making an asphalt overlay) (Puszczykowo Citizens' Budget, 2024).

Since the physical components of the infrastructure are also necessary for non-automated vehicles, these costs will not be taken into account in further estimates.

Virtual components are infrastructure elements that are digital and communicate directly, enabling data exchange, navigation, monitoring and response to traffic situations. V2X (Vehicle-to-Everything) communication systems are crucial to coordinate traffic on a large scale, provide fuel efficiency and raise safety.

- Vehicle-to-Infrastructure Communication: vehicles must be able to communicate with infrastructure elements such as traffic lights, road signs to synchronise traffic and improve safety.
- V2V (Vehicle-to-Vehicle) systems allow vehicles to exchange information, which helps avoid collisions and optimise traffic flow.
- Infrastructure-to-Vehicle communication: real-time information exchange between infrastructure and a technology that is embedded inside a vehicle.

Communication can take place either via (i) Dedicated Short Range Communication (DSRC), which is a radio wave that transmits data directly with a low latency from one point to another, or (ii) Cellular-Vehicle to Everything (C-V2X). In the case of both technologies, their goal is to improve safety through efficient communication between road users as well as key infrastructure elements. Both of them require additional roadside units. DSRC is defined by the 802.11p standard, and it is considered an amendment to the IEEE 802.11 (WLAN) standard. The effective range is to be approximately 1 km, and the effectiveness of the technology and response systems has been confirmed at speeds of up to 500 km/h.

Cellular V2X provides two types of communication – direct (PC5) and indirect (Uu). The direct mode, referred to as device-to-device, uses 5.9 GHz band to work independently of cellular networks, thus allowing for close communication with other road users (cyclists, pedestrians or other vehicles). Indirect mode is network-based. It leverages conventional mobile networks to enable vehicles to receive real-time information about road conditions and local traffic. Therefore, the main difference is that DSRC manages its network independently, while C-V2X system is to be based largely on mobile networks and be quite dependent on them. This means that operators could influence the operation of the system. On the other hand, cellular communication, especially 5G technology supercharges C-V2X, offering low latency, enhanced reliability, and wider range.

The choice of the technology determines costs. According to the United States Department of Transportation, a total cost for Dual Mode DSRC/C-V2X Infrastructure-to-Vehicle (I2V) Pedestrian System in Maryland (2023) was 84 000 USD per intersection (including one-year maintenance). The project used cameras for detection and a private security company credentialing for message exchanges. For cybersecurity, the Security Credential Management System (SCMS) was utilised, which provided the mechanism for V2X devices to exchange information in a trustworthy and privacy protective manner using digital

certificates (Maryland DOT, 2023). DSRC solo was implemented in Gwinnett County, Georgia (2019) costing approx. 15 450 USD per intersection (309 000 USD for 20 intersections).

An inseparable component of cellular V2X communication is a mobile network. The 5G provides a fast and reliable connection between vehicles and infrastructure, enabling immediate response to changing road conditions, such as sudden incidents, changing traffic lights or breakdowns. Compared to 4G, 5G offers up to 50 times lower latency (50 ms vs. 1 ms) and nearly 100 times faster data transmission (up to 10 Gbits/sec) [23]. Moreover, 5G network offers slicing feature that allows operators to create dedicated virtual networks for AVs. Therefore, AVs will have a prioritised, secure bandwidth, without smartphones and other devices, that guarantees fast and reliable communication (Tran, 2025).

The 2023 European Commission's study from four Member States, including Poland, showed medium or low probability of achieving an uninterrupted 5G coverage in all their urban areas and along major terrestrial transport paths by 2025. Figure 2 presents 5G coverage on the territory of Poland (extracted on 15 May 2025), retrieved from Nperf portal, which assesses mobile broadband connectivity based on tests carried out by its users. Please note that the following map only shows coverage, and not performance such as speed and latency.

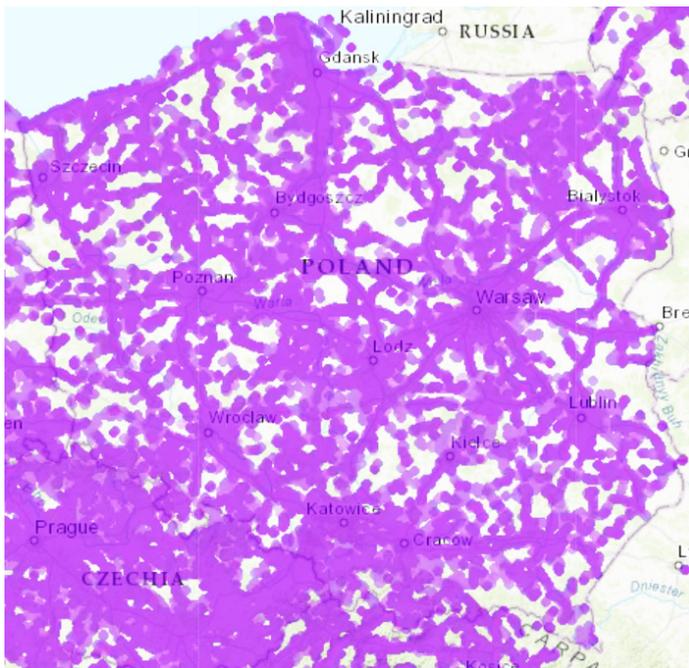


Figure 2. 5G coverage on the territory of Poland (extracted on 15 May 2025, based on nPerf)

Taking a closer look on the capital city (Figure 3), the figure on the left side represents 5G coverage of Warsaw as of 4 October 2021 (extraction date) (European Court of Auditors, 2022). The figure on the right side presents the same city 3.5 years later (extracted on 15 May 2025). It can be seen that 5G connection covers not only the city centre, but the increase in network coverage is noticeable in districts adjacent to the city centre (especially on the left side of the Vistula River). However, the current state of coverage is not sufficient for uninterrupted V2X communication.



Figure 3. 5G coverage on the territory of Warsaw: left – October 2021 (European Court of Auditors, 2022), right – May 2025 (nPerf)

In the report published in 2022 by the Ericsson company, it was estimated that baseline 5G deployment could cost around USD 3–8 billion per country. If extended coverage is required (e.g., for industrial adoption) an additional 20–35% investment is required. The price was estimated given that the country did not make any prior progress (Ericsson, 2022).

In 2021, the CIRE portal reported that the 3,5 GHz frequency, needed for the digitalization of industry, among other things, would cover almost one third of the population and 3% of Poland's territory in 2025. By the end of 2030, the costs of deploying 5G technology will amount to 2 billion euros.

Autonomous vehicles use precise, high-resolution maps that include data on road topography, curves, elevations, access roads, markings, and other details necessary for safe navigation. According to Nexar (Barros, 2023), just recording a location once costs about \$ 30 per mile (1.6 km). But recording is not everything. The data must also be reviewed, collected, and, in some cases, annotated. Hyperspec AI reported (Sonekar & Puttagunta, 2021) that creating an HD map costs about \$ 5000 per kilometre in the U.S.

To implement autonomous vehicles, investments in a real-time traffic management and optimisation system are also necessary, which can collect data from various sources (sensors, cameras, and vehicles) and provide real-time information on traffic conditions, allowing autonomous vehicles to better adjust their route or speed. Sensors and weather monitoring systems are also necessary to inform the vehicle about changing conditions, such as rain, snow, or fog, which can affect safety and driving comfort. Finally, it is worth mentioning that intelligent monitoring systems in cities, such as CCTV cameras and sensors on the road, will provide data on the situation on the road, including accidents, road closures, or other hazards. However, due to the close connection between the mentioned elements and the functionality of V2X communication, this cost will be omitted in subsequent considerations, taking into account primarily the cost and scope of V2X operation in Maryland, the pricing of which was presented earlier.

4. Results

The author decided to estimate and compare accident costs related to human error with potential investments in road infrastructure, which has to be done prior to the implementation of autonomous vehicles. The following assumptions were made:

- AVs would eliminate road events caused by human error (driver);
- there was no need to build additional roads or renovate existing;
- no additional signs were introduced;
- V2X communication should be available at any intersection;
- R&D costs related to AVs were not taken into account;
- all vehicles were autonomous and fault-free.

4.1. Cost of road events caused by human error

According to Polish Police in 2024, 19 636 accidents were caused by drivers' error (91.2% of the total) (Police Headquarters, 2025). Taking into account road accident costs in Poland, the total cost of road events caused by human fault is Equation (1): EUR 11.13 billion/year.

$$\begin{aligned} T_{c_human} &= (\text{cost of accidents} + \text{cost of collisions}) \times \%_{\text{human}} = \\ &= (8.9 \text{ billion PLN} + 3.3 \text{ billion}) \times 91.2\% = 11.13 \text{ billion EUR} \end{aligned} \quad (1)$$

where: T_{c_human} – total cost of road events caused by human error.

4.2. Cost of country-wide DSRC/C-V2X communication

It has been found out that the cost of DSRC/C-V2X is 84 000 USD per intersection. Taking into account exchange rate 1 EUR = 1.1384 USD (Narodowy Bank Polski, 2025), the price is approx. 73 800 EUR. In order to estimate the cost country-wide, the number of intersections is required. Unfortunately, no such data was found. Therefore, an attempt was made to estimate based on population density and representative locality Equation (2).

According to data from the Central Statistical Office published on 24 April 2025, the territory of the Republic of Poland is inhabited by 37 454 000 people living on a land area of 311 888 km² (Statistics Poland, 2025). Thus, the population density is 37 454 000/311 888 = 120 people/km², which is consistent with the information included by the Central Statistical Office in the statistical bulletin (Statistics Poland, 2024).

Given the population density, localities with identical population density were selected – Wodzisław (Świętokrzyskie Voivodeship, Jędrzejów County; 951 Number of inhabitants; 7.9 km² Area; 119.8 persons/km²; Poland in numbers) and Cieszanów (Podkarpackie Voivodeship, Lubaczów County; 1.803 Number of inhabitants; 15.1 km² Area; 119.7 persons/km² Population density; Poland in numbers). For both of them, the number of intersections was counted (without division by type).

The following results were obtained:

- Wodzisław: 95;
- Cieszanów: 55.

Next, taking into account the fact that both cities have different populations and areas, it was decided to use the arithmetic mean of intersections from both locations and their average area Equation (2). Then, the obtained average area of the location with a population density of 120 people/km² was compared to the area of the whole of Poland, and the next proportion was created from the number of intersections in both locations and the unknown in the form of the total number of intersections in the territory of the Republic of Poland.

$$\begin{aligned}
 &Area_{\text{mean W\&C}} \text{ ---- } Area_{\text{Poland}}, \\
 &N_{\text{mean W\&C}} \text{ ---- } N_{\text{Poland}}, \\
 &N_{\text{Poland}} = \frac{N_{\text{mean W\&C}} \times Area_{\text{Poland}}}{Area_{\text{mean W\&C}}}, \\
 &N_{\text{Poland}} = \frac{70 \times 311888}{11.5} = 1898448.69 \approx 1898449, \tag{2}
 \end{aligned}$$

where: $Area_{\text{mean W\&C}}$ – an arithmetic area mean of Wodzisław and Cieszanów;
 $Area_{\text{Poland}}$ – the area of Poland;

$N_{\text{mean W\&C}}$ – an arithmetic mean of intersection number in Wodzisław and Cieszanów;
 N_{Poland} – the number of intersections in Poland.

Therefore, the cost of V2X implementation in Poland is Equation (3):

$$T_{c_V2X} = 73800 \text{ EUR} \times N_{\text{Poland}} = 73800 \text{ EUR} \times 1898449 = 140.1 \text{ billion EUR.} \quad (3)$$

Taking into account 5G investments $T_{c_5G} = \text{EUR } 2 \text{ billion}$, the total price of implementation V2X and 5G Equation (4) is approx. 142.1 billion EUR.

$$T_{c_V2X\&5G} = T_{c_V2X} + T_{c_5G} = 142.1 \text{ billion EUR.} \quad (4)$$

4.3. HD map costs

Mapping of all public roads in Poland, including adding annotations, will amount to Equation (5):

$$T_{c_HD} = 5000 \text{ USD/km} \times L_{\text{Poland}} = 4392 \text{ EUR/km} \times 420000 \text{ km}, \\ T_{c_HD} = 1.84 \text{ billion EUR.} \quad (5)$$

where: L_{Poland} – the length of public roads in Poland; 420 thousand km (General Directorate for National Roads and Motorways, 2022).

4.4. Final calculation

All investment costs (Equations (4) and (5)) can be compared to the costs of human-caused road accidents Equation (1). Given the assumption that autonomous vehicles are fault-free and eliminate human error, the cost of human-caused accidents can be potentially treated as a gain from the introduction of autonomous mobility. However, depending on the chosen technology, the investment should pay off between 1–13 years Equation (6):

$$Y = \frac{T_{c_V2X\&5G} + T_{c_HD}}{T_{c_human}} = \frac{142.1 + 1.84}{11.13} = \frac{143.94}{11.13} = 12.9 \text{ years,} \quad (6)$$

where: Y – the number of years after which the full implementation of infrastructure supporting autonomous vehicles could be compensated by eliminating the costs of accidents caused by human errors.

5. Discussion

As a result of incidents caused by drivers, 1629 people died (85.9%) in Poland in 2024, and 22 924 were injured (92.5%) (Police Headquarters, 2025). It is impossible

to put a price on human life, so any investment that improves road safety should be considered profitable regardless of its amount. Autonomous cars, if designed correctly, will not make the same mistakes as humans, e.g., impaired judgment, inattention or distraction, negligence of basic safety rules, lack of experience, and overconfidence. Moreover, autonomous mobility offers other benefits, including increased accessibility for people with disabilities or elderly individuals, reduced traffic congestion, and lower fuel consumption and emissions.

However, a huge cost in AV implementation is the adaptation of infrastructure. The main expense here is focused on introducing V2X and C-V2X services. The cost estimates for implementing remote communication found by the author referred to one intersection. Unfortunately, none of the offices has information on the total number of intersections in Poland. The author has developed her own estimation methodology, but it is a far-reaching simplification, and the values in this area are burdened with great uncertainty. Nevertheless, no other possibility of estimating the cost of country-wide V2X communication was found. Worth noting is the fact that according to the report of Supreme Audit Office (2025), the President of Warsaw, when managing road traffic, was unable to determine the total length of public roads located in the city, mainly due to too big number of road managers (19 in the city of Warsaw).

The author draws readers' attention to the fact that the presented estimates do not account for inflation-related costs (investments spread over time), exchange rate fluctuations, or infrastructure maintenance costs.

On the other hand, the costs of road accidents published by the National Road Safety Council do not include total costs related to the treatment of mental disorders caused by a road accident (e.g., PTSD). This type of medical service is often associated with long waiting times for the public health service. As a result, most patients are treated privately. This data is therefore not collected, and psychologists are not obliged to register and report the occurrence of disorders in connection with a road accident. The situation of Poland is not unique. As part of the ongoing IMPROVA (HE) project, it was established that this data was also not collected by other members of the European community.

Investment in infrastructure alone is not everything, however. Vehicles are also necessary. Currently, at the R&D phase of AVs it is not possible to give a price of an autonomous car. However, according to the Patent PC portal, the cost of retrofitting a vehicle in advanced sensors, AI computing, and redundant safety features exceeds \$ 100 000 per vehicle (Tran, 2025) (approx. 373 440 PLN, 87 900 EUR). Given a mean price of a new car in Mazowieckie voivodeship (Kamiński, 2025) of 189 555 PLN (approx. 44 600 EUR), the cost of a new vehicle equipped with the necessary technologies is estimated at 562 995 PLN (132 500 EUR). This is an expense that would only partly be borne by the state (e.g., purchase of new buses). Most of this

cost would be borne by society. Unfortunately, current earnings in Poland are insufficient to purchase such a vehicle.

It should be noted that the estimates presented in the article could be extended to include additional possible infrastructure changes. First, road condition could be improved. Second, the Supreme Audit Office reported in May 2025 that there was "information chaos" regarding road marking on many sections of public roads in Poland. On 63% of road sections subject to the inspection, cases of non-compliance of the implemented traffic management projects with the provisions of the law were found. In turn, on 48% of road sections, road signs and road safety devices (i.e., road safety devices, e.g., barriers, speed bumps) were placed that were not included in the approved traffic management projects.

Additionally, further innovations are possible, such as roads equipped with sensors that monitor traffic conditions, road surface temperature, presence of obstacles and other data that autonomous vehicles can use to improve driving safety and efficiency.

Conclusions

This study examined the economic feasibility of achieving the aims of the "Vision Zero" strategy through the large-scale implementation of AV infrastructure in Poland. By comparing the annual societal cost of traffic accidents caused by human error with the estimated investment required for V2X, HD mapping, and 5G network deployment, the analysis highlights the potential for long-term financial and social benefits of automated mobility systems.

The findings suggest that, under optimistic assumptions, the full deployment of AV-supporting infrastructure –amounting to approximately EUR 143.94 billion – could be offset within roughly 13 years through the elimination of human-error-related accident costs. This result underscores the significant potential of AV technologies to contribute not only to road safety but also to broader economic resilience and efficiency.

However, these conclusions must be interpreted with caution. The model assumes full substitution of human drivers with autonomous systems and does not account for transitional phases, regulatory constraints, behavioural adaptation, or unforeseen technological challenges. Future research should refine these estimates by incorporating dynamic adoption rates, mixed-traffic scenarios, and cost variations across urban and rural contexts.

Despite these limitations, the analysis provides a quantitative starting point for assessing when and how investments in automated mobility infrastructure may begin to pay off. It also reinforces the notion that the pursuit of "Vision Zero"

involves not only technological innovation but also strategic policy planning and sustained financial commitment.

Author Contributions

Author is solely responsible for all steps of manuscript development: study conceiving, data analysis, data interpretation, writing.

Disclosure Statement

The author does not declare any competing financial, professional, or personal interests from other parties.

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